INSTRUCTION MANUAL

5000
DIGITAL VOLTMETER

DANA®

VIKING LABS / HONEYWELL
370 BERNARDO AVENUE
MOUNTAIN VIEW, CA 94043

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5000
DIGITAL VOLTMETER

DANA LABORATORIES, INC.
2401 CAMPUS DRIVE
IRVINE, CALIFORNIA 92664

DANA®

TELEPHONE (714) 833-1234
TELETYPE 910-595-1136
TELEX 678-341

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WARRANTY

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1.1 INTRODUCTION.

1.2 The Model 5000 Digital Voltmeter (figure 1.1) is a five-digit "Delayed Dual Slope" instrument with a sixth decade providing 100% overrange. The basic instrument is equipped for dc measurements on five ranges. With the addition of the Model 34 Averaging AC Converter on the Model 44 RMS AC Converter, ac measurements on four ranges are available. The Model 54 Ohms Converter, also optional, adds ohms measurements on six ranges. Four-wire dc/dc ratios are provided by Model 64 Ratio option. Complete measurement capability is tabulated in table 1.1.

Table 1.1 - Measurement Capability

Range	FUNCTION			
	DC (Basic 5000)	DC/DC RATIO (Model 64 Ratio)	Ohms (Model 54 Ohms Converter)	AC (Model 44 or 34 AC Converter)
.1V				
1V				
10V				
100V				
1000V				
.1 KΩ				
1 KΩ				
10 KΩ				
100 KΩ				
1000 KΩ				
10000 KΩ				

1.3 Range can be selected manually or automatically (autorange). In AUTO range, the proper range for a particular measurement is selected automatically (full scale is defined as "100000" on any range). The instrument "upranges" at 200% of full scale and "downranges" at 10% of full scale. Polarity selection is also automatic and is displayed on the readout.

1.4 Also included as optional equipment is a solid-state systems interface including BCD output and remote programming (Model 94). TTL-compatible output levels of the reading, function, range, etc., plus a print command are provided as outputs. The remote programming unit allows all operating commands to be made externally.

1.5 Two operating modes are provided. With the front panel PERIODIC/HOLD switch in PERIODIC, measurements are taken automatically at the rate of five per second. In HOLD position, the display "holds" the last reading. In HOLD and REMOTE operation, with option 94, the last reading is held until an external read command is received through the DATA OUTPUT or PROGRAMMING connector.

1.6 OPTIONS.

1.7 All optional accessories are plug-in circuit boards. The Model 54 Ohms Converter, Models 44 and 34 AC Converters, the option 94 Systems Interface accessory, and the Model 64 Ratio option can be plugged into the instrument at any time. Installation of the Ratio board requires the removal of jumpers W1 and W2 located next to connector J4 on the motherboard. Other options include the following.

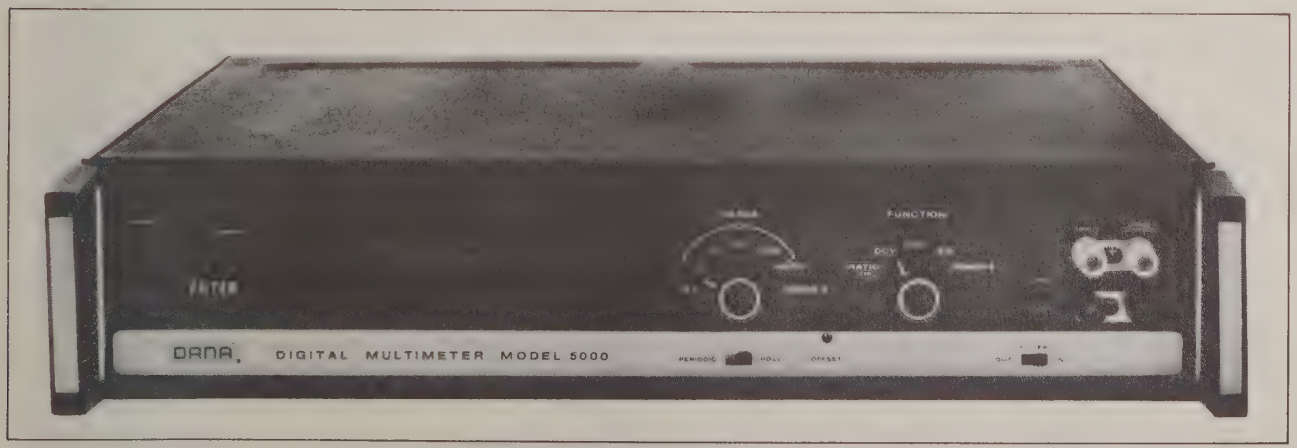


Figure 1.1 - Model 5000

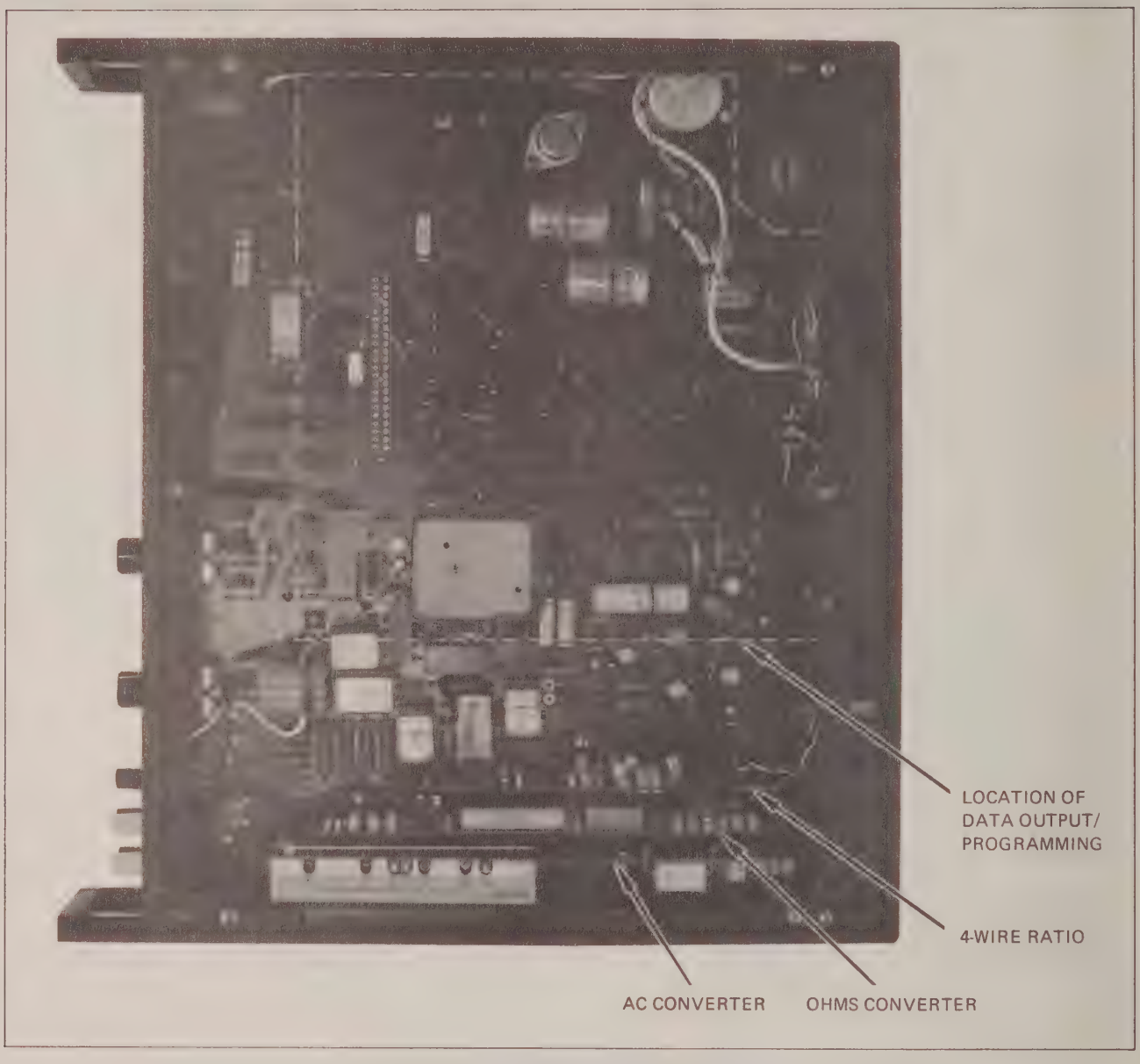


Figure 1.2 - Locations of Accessories

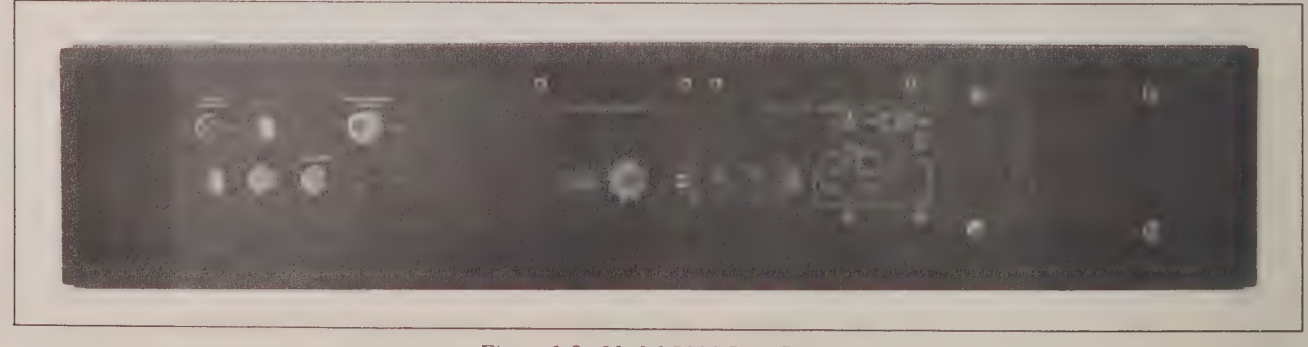


Figure 1.3 - Model 5000 Rear Panel

1.8 Parallel Front/Rear Input.

1.9 This option permits use in a wide variety of applications in which input requirements may vary. Rear input is especially useful when the instrument is rack mounted. Instruments equipped with this option are designated 5000-1.

1.10 Extender PCB Kit (403701).

1.11 This kit consists of three extender boards used to elevate PC boards to an accessible position when servicing the instrument. This kit is not required for calibration.

1.12 Rack-Mounting Flanges (403402).

1.13 Rack-Mounting Flanges are used where the instrument is to be installed in a relay-rack or cabinet.

1.14 Current Shunt Set (651) (402315).

1.15 The Current Shunt Set consists of six precision shunt assemblies with values selected to produce a voltage drop that, measured in millivolts, has a numerical value equal to the current flow in milliamps or microamps.

1.16 ELECTRICAL DESCRIPTION.

1.17 The Dana Model 5000 Digital Voltmeter consists of three parts: the Signal Conditioning section, the Digital section, and the Analog-to-Digital (A/D) converter.

1.18 The A/D converter changes a dc signal fed into it into a representative digital signal. The method used to perform this task is called Delayed Dual Slope integration.

1.19 The digital section measures the output of the A/D converter to produce a numeric value on the instrument display that represents the value of the input signal. The digital section also provides range control, decimal placement, programming and BCD output.

1.20 The signal conditioning section modifies the input signal before reaching the A/D converter. For dc measurement, the input signal is scaled if required to a 5 volt full-scale signal and filtered if required. For ac or resistance measurement, the input signal is scaled if necessary and converted to a proportional dc value. The dc value is filtered if necessary and routed to the A/D converter.

1.21 MECHANICAL DESCRIPTION.

1.22 The Readout and all accessory PCB's plug into connectors on the Interconnection PCB ("motherboard"). Locations are shown in figure 1.2. The Program PCB (Systems Interface option, not shown) is mounted on standoffs above the Interconnection board. J208, the DATA OUTPUT connector, and J209, PROGRAMMING connector, are extensions of the Program board that extend through openings in the rear panel for external access.

1.23 Figure 1.3 shows the rear panel of the instrument. Mounted on the panel, in addition to the DATA OUTPUT and PROGRAMMING connectors, are the ± REFERENCE INPUT connectors, power connector, line fuse, and the AC LINE INPUT VOLTAGE switch. Location of the optional parallel rear input connectors are on the left of the panel. These are binding posts that duplicate the front panel connectors.

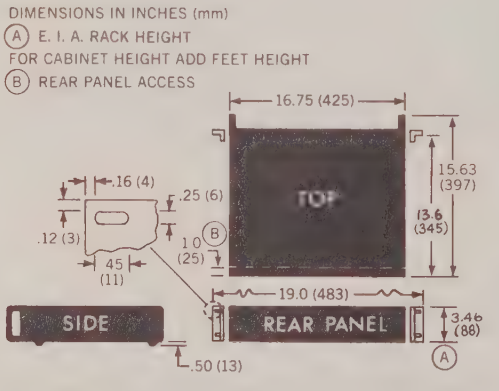
1.24 SPECIFICATIONS.

1.25 Specifications are listed in table 1.2.

Table 1.2 - Specifications

GENERAL	
Ranging:	Automatic or manual
Digitizing Technique:	Dual Slope Integrator
Integration Time:	50 msec domestic 60 msec export
Digitizing Time:	200 msec domestic 240 msec export
Maximum Common Mode Voltage:	500V Guard to Case 250V Analog Com to Guard
Maximum Power Requirements:	Optional: 100, 115, 120, 220, 230, 240V RMS ±10%; 50 to 400 Hz, 40 watts maximum
Operating Temperature:	0 to 50°C
Warm Up:	2 hours to full stability
Weight (Approx):	17 pounds (7.7 kg) net, 20 pounds (9 kg) shipping
Guarantee:	12 months against faulty workmanship or component failure

Dimensions:



DC VOLTAGE	
Full Range Display:	±.100000, ±1.00000, ±10.0000, ±100.000, ±1000.00
Overrange:	100% on all ranges, 1000V DC or RMS AC maximum input
Resolution:	1 microvolt on .1V range
Accuracy:	24 hours, 23°C ± 1°C .1V range ±(0.005% of reading +0.005% of full scale) 1V – 1000V range ±(0.005% of reading +0.001% of full scale) 6 months, 23°C ± 5°C .1V range ±(0.01% of reading +0.005% of full scale) 1V – 1000V range ±(0.01% of reading +0.002% of full scale)
Temperature Coefficient:	0 to 50°C .1V range ±(0.002% of reading +0.002% of full scale)/°C 1V – 1000V range ±(0.001% of reading +0.0003% of full scale)/°C
Input Resistance:	.1V range 1,000 megohms minimum 1V range 10,000 megohms minimum 10, 100, and 1000V ranges 10 megohms
Normal Mode Noise Rejection:	At or near 60 Hz* Filter in: 80 dB (10,000 to 1) Filter out: 54 dB (500 to 1)
Common Mode Noise Rejection:	Up to 100Ω in either lead: DC and at 60 Hz* 140 dB minimum
Settling Time to 0.01% of Full Scale Step Input:	Filter in: 600 msec maximum Filter out: 30 msec maximum

*50 Hz with Option 04

Table 1.2 - Specifications *(Continued)*

WIDEBAND AC VOLTAGE (With addition of Model 34 AC Converter)	
Full Range Display:	1.00000, 10.0000, 100.000, 1000.00V RMS
Overrange:	100% on all ranges; Maximum Voltage Rating: 1000 volts to 10 kHz, decreasing linearly to 100V RMS at 100 kHz. Maximum input voltage x frequency should be less than $2x10^7$ Volt-Hz.
Resolution:	10 microvolts
Accuracy: (for inputs $\geq$ 500V add: .01% of reading)	6 months, 23°C ± 5°C 30 Hz to 50 Hz ±(0.20% of reading +0.02% of full scale) 50 Hz to 30 kHz ±(0.10% of reading +0.02% of full scale) 30 kHz to 100 kHz ±(0.15% of reading +0.02% of full scale) 100 kHz to 250 kHz 1, 10, 100 ranges ±(1% of reading +0.10% of full scale)
Input Resistance:	1 megohm in series with .22 μF
Shunt Capacitance:	100 pF front, 200 pF front/rear
Common Mode Noise Rejection:	Up to 100 ohms in either lead At line frequency $>$ 80 dB
Settling Time to 0.1% of Full Scale Step Input:	600 msec maximum
Temperature Coefficient: 0°C to 50°C	30 Hz to 30 kHz ±(.01% of reading +.002% of full scale)/°C 30 Hz to 250 kHz ±(.05% of reading +.005% of full scale)/°C

AC VOLTS TRUE RMS (Model 44)	
Ranges:	1.00000V, 10.0000V, 100.000V, 1000.00V RMS
Resolution:	0.001% of range 10 μV on 1V range
Overrange:	100% (within maximum input voltage limit)
Maximum Input Voltage:	1000V DC/RMS or 1500V peak, decreasing to 20V RMS at 1 MHz. $2x10^7$ VHz maximum on any range
Maximum Crest Factor:	7:1 at full-scale $7 \times \sqrt{\frac{F.S.}{V_{in}}}$ for other voltages
Accuracy: Sine Wave Input AC Mode (AC/DC select switches located on option board and accessible through shield)	90 days, 25°C ± 5°C $.1 \leq V_{in} \leq 200\%$ 10 Hz – 20 Hz ±(2% of reading +.04% of full scale) 20 Hz – 30 Hz ±(.5% of reading +.04% of full scale) 30 Hz – 50 Hz ±(.25% of reading +.04% of full scale) 50 Hz - 20 kHz ±(.11% of reading +.04% of full scale) 20 kHz – 50 kHz ±(.1% of reading +.1% of full scale) 50 kHz – 100 kHz ±(.4% of reading +.2% of full scale) 10, 100, 1000V range 100 kHz – 300 kHz ±(3% of reading +.5% of full scale) 1V range 100 kHz – 300 kHz ±(5% of reading +1% of full scale)
AC & DC Mode	Add .02% of full scale to AC specification

Table 1.2 - Specifications *(Continued)*

AC VOLTS TRUE RMS continued	
For inputs greater than 500V add: .1% of reading	
Temperature Coefficient:	0°C to 50°C AC Mode (to 20 kHz) ±(.005% of reading +.003% of full scale)/°C AC & DC Mode (to 20 kHz) ±(.005% of reading +.005% of full scale)/°C
Input Impedances: AC Mode DC Mode	1 Megohm ±0.1% in series with 0.22 μF shunted by less than 100 pF to common Same with .22 μF shorted
Common Mode Rejection:	With 100Ω unbalance in either lead DC and 60 Hz: 80 dB
Settling Time:	To within .1% of range 600 msec maximum

RESISTANCE (4-WIRE OHMS) (With addition of Model 54 Ohms Converter)	
Full Range Display:	.100000, 1.00000, 10.0000, 100.000, 1000.00, and 10000.0 kilohms
Overrange:	100% on all ranges Fault Voltage: All ranges: 250V
Resolution:	1 milliohm
Accuracy:	6 months, 23°C ± 5°C .1 kilohm range ±(0.02% of reading +0.005% of full scale) 1, 10, 100 kilohm ranges ±(0.01% of reading +0.002% of full scale) 1000 kilohm range ±(0.02% of reading +0.002% of full scale) 10,000 kilohm range ±(0.03% of reading +0.002% of full scale)
Settling Time to 0.01% of Full Scale Step Input:	Filter in: 600 msec Filter out: ≤ 50 msec
Current Through Unknown:	.1 kilohm range 1.0204 milliampere 1 kilohm range 1.25 milliampere 10 kilohm range 125 microamperes 100 kilohm range 50 microamperes 1000 kilohm range 5 microamperes 10,000 kilohm range 0.5 microampere
Temperature Coefficient: 0°C to 50°C	.1 kilohm range ±(.002% of reading +.004% of full scale)/°C 1, 10, 100 kilohm ranges ±(.002% of reading +.002% of full scale)/°C 1000 kilohm range ±(.003% of reading +.002% of full scale)/°C 10,000 kilohm range ±(.005% of reading +.002% of full scale)/°C

Table 1.2 - Specifications *(Continued)*

DC/DC 4-WIRE RATIO – 4-QUADRANT (With addition of Option 64)	
Full Range Display:	±.100000:1, ±1.00000:1, ±10.0000:1, ±100.000:1, and ±1000.00:1 (Readout is Ratio x 10)
Overrange:	100% on all ranges, ±1000 volts maximum input
Accuracy:	6 months, 23°C ± 5°C .010000:1 range ±[0.02% of reading +0.005% (10V/ref) of full scale] .100000:1 to 100.000:1 range ±[0.01% of reading +0.002% (10V/ref) of full scale]
Voltage Range:	Input Sig (Numerator) 0 to ±1000V Reference Sig (Denominator) ±2 to ±11V
Ref Overload Voltage:	300 volts maximum (with – Ref input tied to signal common – input)
Input Resistance: (Sig Input/ Ref Input)	.01:1 range 1,000 megohms/ 1 megohm .1:1 range 10,000 megohms/ 1 megohm 1:1, 10:1, 100:1 ranges 10 megohms/ 1 megohm
Normal Mode Noise Rejection, Common Mode Noise Rejection, and Settling Time:	Same as DC specifications

SECTION 2 INSTALLATION & OPERATION

2.1 UNPACKING AND INSPECTION.

2.2 The Model 5000 DVM is packed in a molded plastic-foam form within a cardboard carton for shipment. The plastic form holds the DVM securely in the carton and absorbs any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for any signs of damage. Carefully remove the DVM from the carton and inspect the exterior of the instrument for any signs of damage. If damage is found, notify the carrier immediately.

2.3 Included with the instrument in the packing container are the instruction manual, power cord, and programming and BCD output mating connectors if a Model 5000-94 is ordered.

2.4 BENCH OPERATION.

2.5 Each Model 5000 is equipped with a tilt bail or "kickstand" to enable the front of the instrument to be elevated for convenient bench use. The tilt bail is attached to the two front supporting "feet" at the bottom of the instrument. For use, the bail is pulled down to its supporting position.

2.6 RACK MOUNTING.

2.7 The instrument can be mounted in a standard 19-inch rack with the optional rack-mounting flanges (403402, includes attaching hardware). To install the flanges, proceed as follows:

a. With instrument on its side, remove four Phillips-head screws holding bottom cover. Remove cover. Remove screws holding feet (and bail) in place. Replace bottom cover.

b. Place one of the supplied screws through each of the two holes in the mounting flange (figure 2.1). Thread a securing nut onto each screw just enough to attach it to the screw (approximately one turn).

c. Place the mounting flange onto the mounting slot in the instrument side panel so that the securing nuts fit entirely into the slot. Be sure the rack-mount slots on the flange are toward the front of the instrument.

d. Tighten screws. The securing nuts will rotate and hold the flange securely in place.

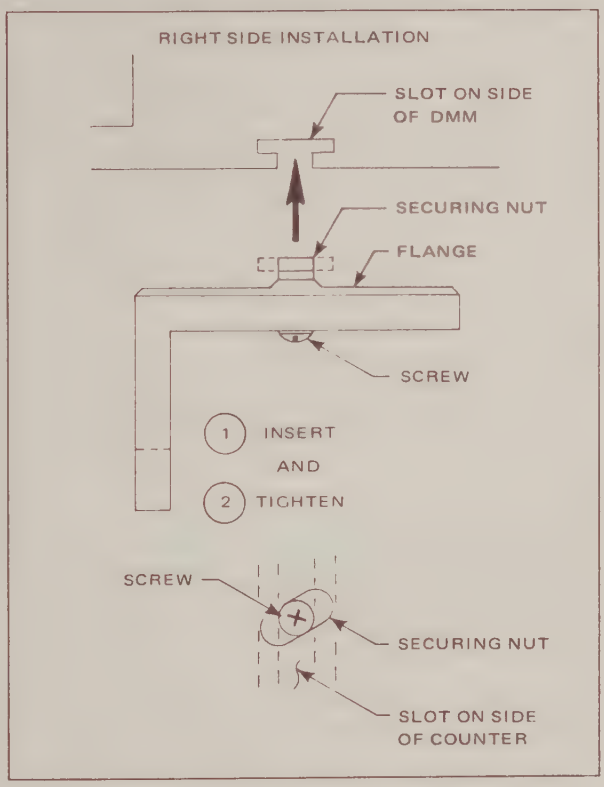


Figure 2.1 - Rack Mount Installation

2.8 POWER CONNECTIONS.

2.9 Power requirements are 115V ± 10%, 50 to 400 Hz. Power consumption is 40 watts maximum. Line voltage is selected by two slide switches on the rear panel, S6 and S7 (see figure 1.7). They are set according to table 2.1.

Table 2.1 - Line-Voltage Selection

S7	S6		
High	220V*	230V*	240V*
Low	100V	115V	120V

*Requires 1/4 amp fuse; other voltage selections require 1/2 amp fuse

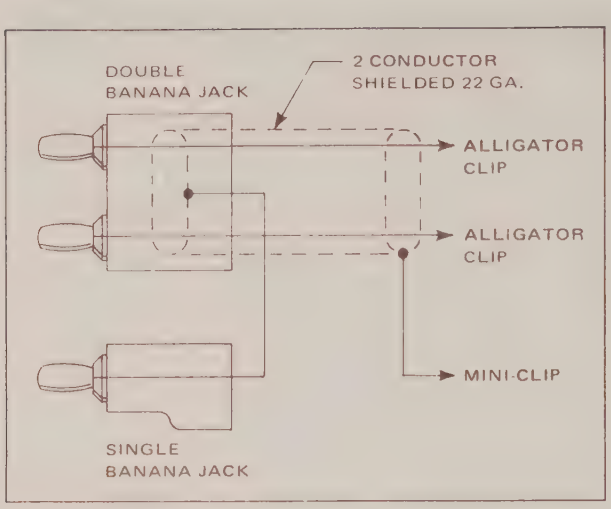


Figure 2.2 - Cabling Diagram, Binding Posts

2.10 A standard power cable having a three-pin plug is supplied with the instrument. It connects to POWER connector J200. The ground pin (round) is attached to the instrument case. It is important that this pin be connected to a good quality earth ground.

2.11 Fuse receptacle F1 on the rear panel is equipped with a .5 amp fuse for 115V (nominal) operation. For high line-voltage operation, use .25 amp fuse (see table 2.1).

2.12 CONNECTORS AND CABLES.

2.13 The following connectors consist of a pair of binding posts spaced so as to accept standard "banana" plugs:

Front Panel

± INPUT
± OHMS CURRENT

Rear Panel

± INPUT
± OHMS CURRENT } (with rear input option)
± REFERENCE INPUT (with ratio option)

2.14 On both front and rear panels, GUARD is a single binding post.

2.15 Input cables to fit this type of connector can be ordered from Dana (P/N 402190). Figure 2.2 is a wiring diagram of this cable included for assistance to users desiring to construct their own cables.

2.16 Double-edged PCB connectors are used for the optional DATA OUTPUT and PROGRAMMING connectors. Mating connectors are:

DATA OUTPUT – Viking 2VH22/1JN5
(Dana Kit P/N 403715)

PROGRAMMING – Viking 2V15/1JN5
(Dana Kit P/N 403714)

2.17 CONTROLS AND READOUT.

2.18 Controls.

2.19 All operating controls are located on the front panel of the instrument. They are shown in figure 2.3 and described in table 2.2.

2.20 Readout.

2.21 Numerical output is displayed on seven-segment LED's (light-emitting diodes). All but one non-significant zero is blanked. An annunciator unit indicates function (AC, DC, Kilohm, or Ratio), filter (in or out), and overload (OL). Overload is indicated by blanking of the numerical display, in addition to energizing of the OL annunciator.

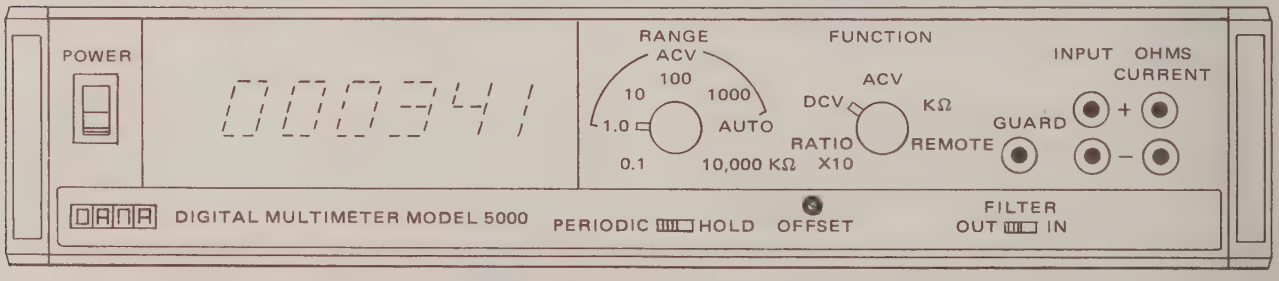


Figure 2.3 - Front Panel

Table 2.2 - Operating Controls

Control	Position	Function
POWER (rocker switch)	ON (up)	Applies power to instrument
	OFF (down)	Removes power from instrument
FUNCTION (rotary switch)	RATIO X10	Selects a measurement of the ratio of the input voltage (applied at either the front or rear ± INPUT terminals) to a reference voltage (applied at the rear panel ± REFERENCE INPUT terminals) multiplied by 10
	DCV	Selects the measurement of DC voltage on the 0.1, 1, 10, 100, or 1000 volt ranges
	ACV	Selects the measurement of AC voltage on the 1.0, 10, 100, or 1000 volt ranges
	KΩ	Selects the measurement of resistances on the 0.1, 1, 10, 100, 1000, and 10,000 kilohm ranges
	REMOTE	In this position, the front panel controls are disabled; control of the instrument is by selections and commands applied at the PROGRAMMING connector (J208) on the rear panel
RANGE (rotary switch)	Fixed Ranges	Enables manual selection of the indicated ranges. Ranges permissible for each function are inscribed on the panel
	AUTO	Selects Autorange in which the optimum range is selected automatically by internal circuits. Uprange occurs at 200% of full scale; downrange occurs at 10% of full scale
PERIODIC/HOLD (slide switch)	PERIODIC	This position selects a periodic read rate of approximately 5/second
	HOLD	In this position, a reading is held and displayed until a read command is applied to the PROGRAMMING input connector or until this switch is returned to PERIODIC
FILTER	IN	In this position, a broadband filter is installed in the input circuit for additional noise rejection. DC settling time is increased to 600 msec (maximum)
	OUT	In this position, the input filter is removed. DC settling time is 50 msec (maximum)

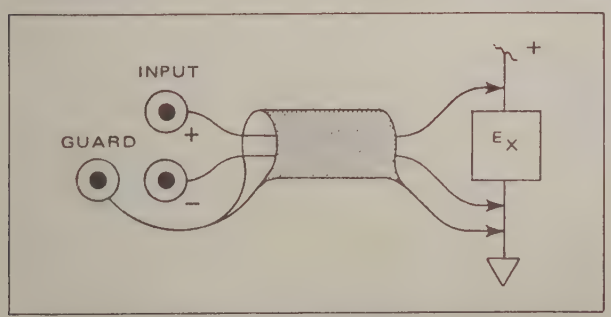


Figure 2.4 - Basic Voltage Measurement Connections

2.22 BASIC MEASUREMENT CONNECTIONS.

2.23 An ac or dc voltage measurement connection recommended to minimize the effects of noise requires a two-conductor shielded cable connected as shown in figure 2.4.

2.24 For all voltage measurements, the GUARD lead and the – INPUT lead are connected to the measurement point nearest ground potential. Somewhat less shielding is achieved by placing a shorting bar between – INPUT and GUARD and shorting the single banana plug (shield) to the – INPUT

side of the double banana plug at the input connector. This arrangement is adequate for measuring all but low voltage (mV) levels and/or in high-noise environments.

NOTE

Before taking any measurements, refer to the list of maximum input voltages, table 2.3.

Table 2.3 - Maximum Input Voltage

CAUTION

Do not exceed the following maximum inputs:

DC	1000 VDC or peak AC
AC	1000 RMS to 10 kHz decreasing to 100V RMS at 100 kHz
RATIO	Reference: 300V Max. Input: same as function selected
OHMS	With + OHMS CURRENT terminal connected to + INPUT: 250V DC or RMS AC maximum

2.25 When making "floating" voltage measurements (both measurement points above ground potential), do not connect GUARD to measurement ground without making sure that the voltage between GUARD and – INPUT does not exceed 250 volts and GUARD to case does not exceed 500 volts.

2.26 Ohms Measurement.

2.27 Ohms measurement in the Model 5000 consists of the application of a known current through the unknown resistance (R_X) and measuring the ratio of the voltage drop across R_X to the drop across an internal "full-scale" resistor (E_{RX}/E_{FS}). Current through R_X is applied through leads from the ± OHMS CURRENT terminals. The voltage drop is sensed by the ± INPUT terminals.

2.28 Connection for a simple two-wire shielded ohms measurement is shown in figure 2.5. It consists simply of a single-conductor shielded cable with the conductor serving as both the + CURRENT and + INPUT leads and the shield carrying – CURRENT and – INPUT. While reasonably accurate measurements can be made with this method, shunt leakage problems result from the parallel combinations of R_X and the cable impedance. This causes loss of accuracy, especially at high resistance (10 MΩ range).

2.29 In most system applications, the device to be measured is located at a remote location requiring interconnection by cables of lengths from several to possibly hundreds of feet. When measuring low resistance values over long cables, most lead resistance problems can be solved by the use of a four-wire measurement system.

2.30 For high resistance measurements over long cables, other problems are encountered: noise pick-up, leakage resistance, and capacitive loading of the system. These problems can be minimized by proper shielding.

2.31 Figure 2.6 shows a basic shielded four-wire ohms measurement configuration. This method uses two single-conductor shielded teflon cables. The conductors carry the positive sides of the INPUT and CURRENT lines while each shield carries the low side.

2.32 Ratio Measurements.

2.33 Ratio measurements are made by applying a ± d-c voltage to the reference input terminals on the rear panel and a DC input signal at the front input terminals. The reference voltage must not exceed 300 volts or damage may

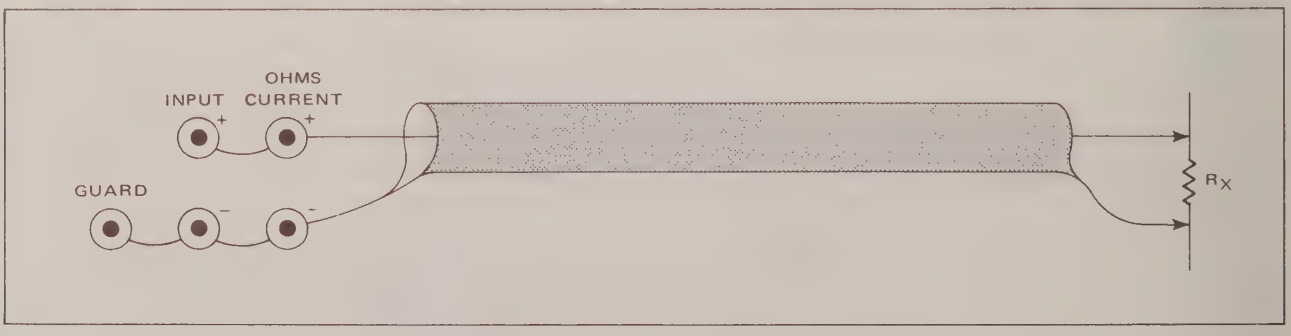


Figure 2.5 - Two-Wire Ohms Measurement

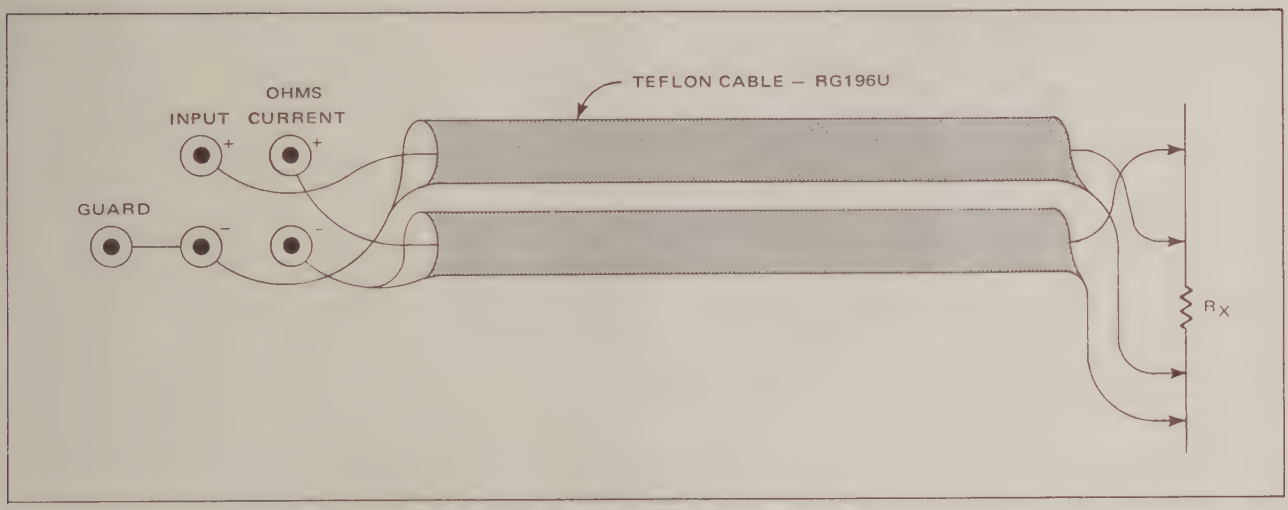


Figure 2.6 - Four-Wire Ohms Measurement

occur. Input signal limitations (numerator) are the same as those given for conventional measurement of the particular function (table 2.3). The readout is the ratio multiplied by ten: $E_{input}/E_{reference}$ x 10. The reference voltage range is ±2 to ±11 volts.

2.34 In instruments equipped with the remote programming option, it is possible to select AC/DC and Ohms/DC ratios in addition to DC/DC ratio.

2.35 DATA OUTPUT (With Option 94, Systems Interface).

2.36 Isolated BCD output data is available at connector J209 on the rear panel in positive-true 1-2-4-8 format at TTL logic levels (2.4 to 5.0 volts, true; 0 to 0.4V false). Pin assignments of J209 are shown in figure 2.7. Logic levels are referenced to digital common, pin B1.

2.37 Numerical Data.

2.38 Numerical data appears in four-line BCD code on the pins shown in figure 2.7. The data is identified by decade and BCD weight. Polarity is indicated by a true logic level on pin A9 (positive) or A10 (negative).

CAUTION

True output lines are not short-circuit proof. Accidental grounding may damage the output circuitry.

2.39 Function Data.

2.40 DC output data is indicated unless there is a true level on pin A1 (AC), pin B2 (KΩ), or pin A2 (ratio).

2.41 FILTER In/Out.

2.42 Filtered measurements are indicated by a true level on pin B5. A false level indicates the filter is out.

2.43 Range Data.

2.44 Range data appears in four-line BCD code on pins A14 through A17. Range codes are identified in table 2.4.

2.45 PRINT Command.

2.46 The print line, pin A11, is true after the signal and reference integration periods are complete. The print command goes true during the time data is being transferred through guard to the storage registers. It drops to a false

Table 2.4 - Range Output Codes

Range	R_1 (Pin A15)	R_2 (Pin A17)	R_4 (Pin A16)	R_8 (Pin A14)	Dec Value
X	1	0	0	0	1
X	0	1	0	0	2
.1 KΩ, .1V	1	1	0	0	3
1 KΩ, 1V	0	0	1	0	4
10 KΩ, 10V	1	0	1	0	5
100 KΩ, 100V	0	1	1	0	6
1000 KΩ, 1000V	1	1	1	0	7
10 MΩ	0	0	0	1	8
X	1	0	0	1	9

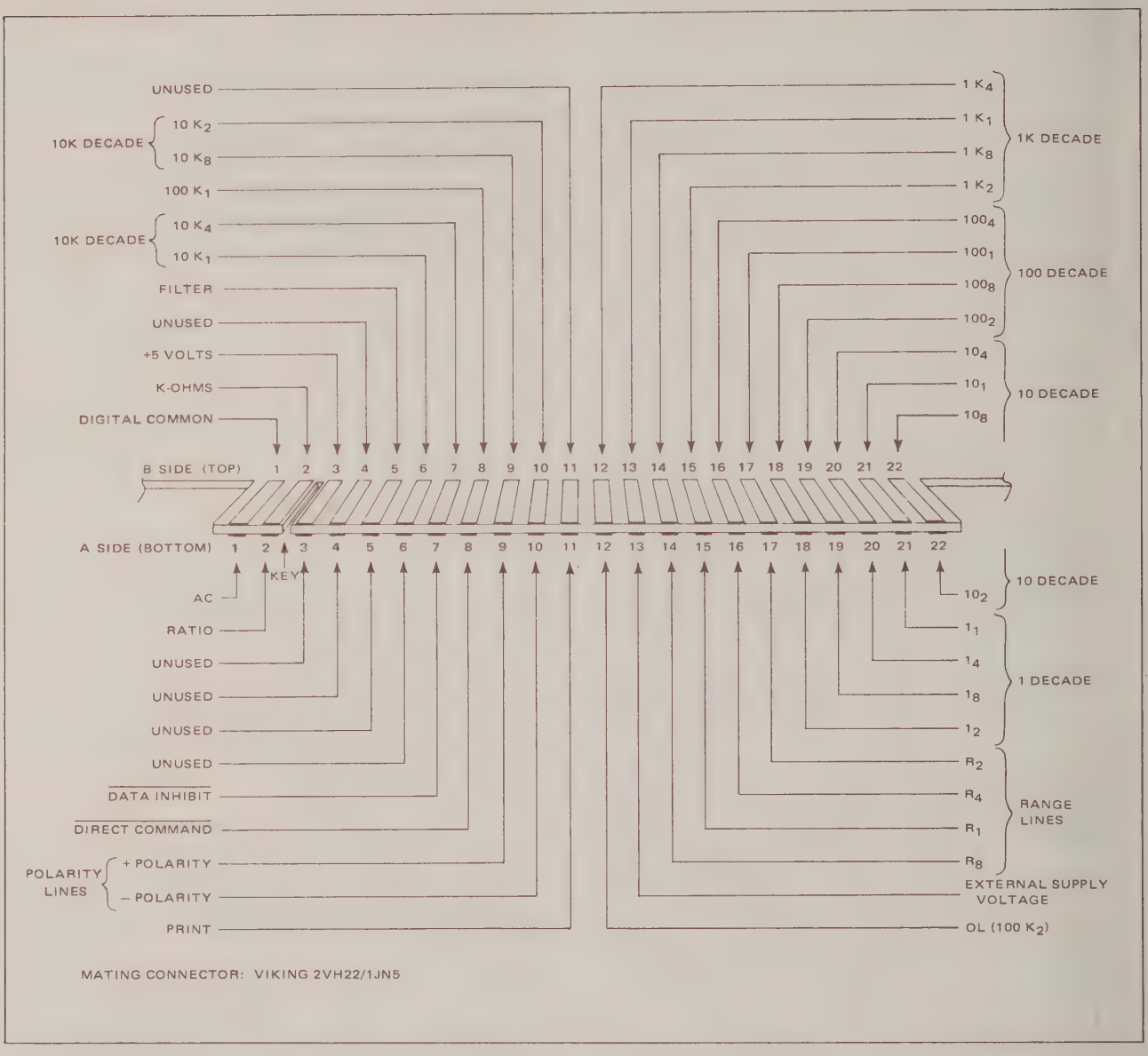


Figure 2.7 - J209 DATA OUTPUT Connector

level 5 msec later to indicate to the printer that the measurement is complete and output data can be printed. The print command is enabled during periodic mode and after a read command in hold mode.

2.47 Overload (OL).

2.48 This line, pin A12, duplicates the OL indicator on the readout. Overrange is indicated by a true level on this line plus a "2" in the 100K bit position printout.

2.49 $\overline{\text{DATA INHIBIT}}$.

2.50 A false logic level (or a contact closure to common, pin B1) on this line, pin A7, inhibits the print command (A11).

2.51 $\overline{\text{DIRECT COMMAND}}$.

2.52 A contact-closure to common or a false logic level on this line commands a new reading. But first, the instrument must be placed in the hold mode by a hold command

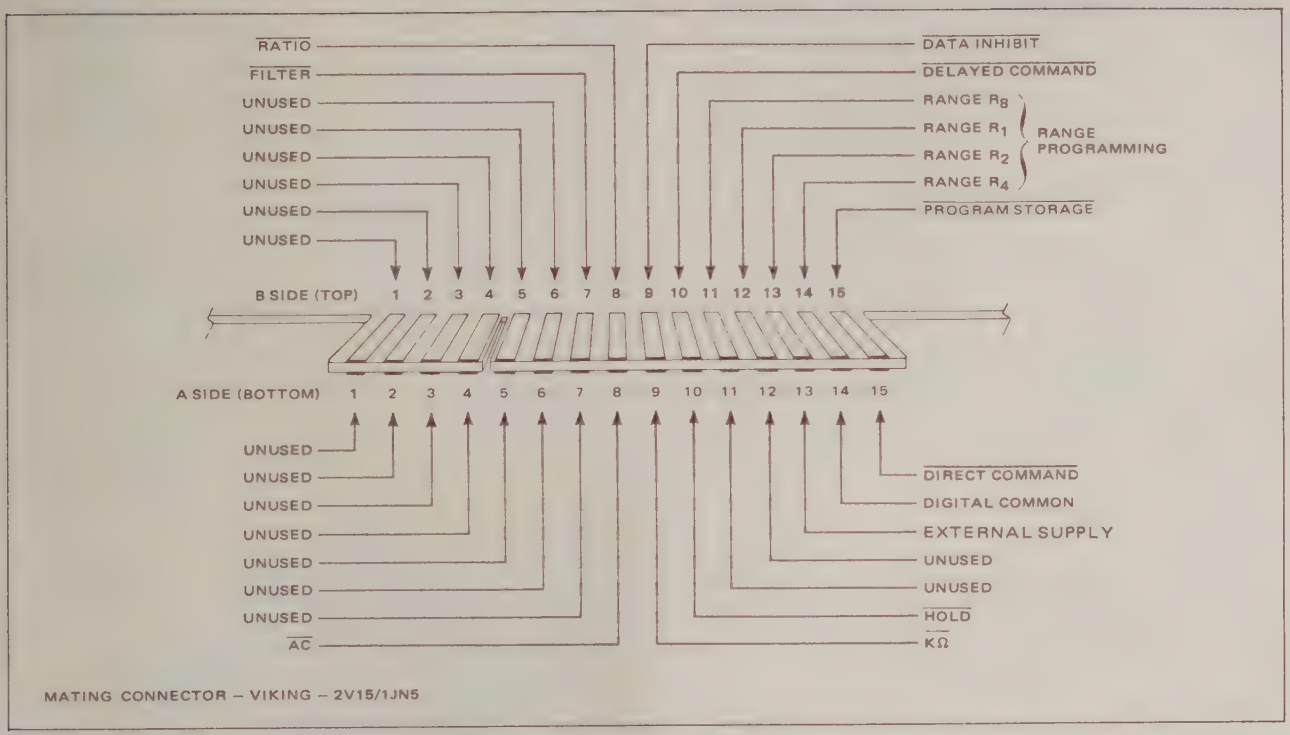


Figure 2.8 - Pin Assignments – J208 Programming Connector

made through pin A10 of J208, the PROGRAMMING connector.

2.53 +5 Volts.

2.54 This voltage, 5V ± 5%, from the logic power supply, is available at pin B3 for external use. Current output is .1 amp, maximum.

2.55 External Supply Voltage.

2.56 Voltage levels other than those provided by the internal 5-volt supply can be obtained by applying the desired voltage to pin A13. Jumper W5 on the program board must be opened and appropriate pull-up resistors installed.

2.57 REMOTE PROGRAMMING (With Option 94, Systems Interface).

2.58 For remote control of the instrument, the FUNCTION switch on the front panel must be set to REMOTE. In this position, the operating controls are disabled. The instrument is then controlled by commands made through the PROGRAMMING connector, J208, on the rear panel of the instrument. Pin assignments of J208 are shown in figure 2.8. Commands are in the form of contact-closures from the appropriate pin to digital common (A14) or by standard TTL logic levels (0 to .5V, false; +2.4 to 5.0V, true) with respect to digital common.

2.59 Function.

2.60 Function is programmed by a contact-closure to common or a false logic level to the appropriate pin (table 2.5). DC function is selected automatically with no other function programmed.

Table 2.5 - Function Programming

Function	Pin No.
$\overline{DC}$	None
$\overline{AC}$	A8
$\overline{K\Omega}$	A9
$\overline{RATIO}$	B8

2.61 The FILTER line, pin B7, duplicates the FILTER IN/OUT switch on the front panel. A contact-closure to common or false logic level to this pin selects FILTER IN.

2.62 Range.

2.63 Fixed ranges are programmed by a positive-true BCD code applied to the four range lines according to table 2.6. With no ranges programmed, autorange is selected.

Table 2.6 - Range Programming Codes

Range	R1 (Pin B12)	R2 (Pin B13)	R4 (Pin B14)	R8 (Pin B11)
AUTORANGE	1	1	1	1
.1V, .1 KΩ	1	1	0	0
1V, 1 KΩ	0	0	1	0
10V, 10 KΩ	1	0	1	0
100V, 100 KΩ	0	1	1	0
1000V, 1 MΩ	1	1	1	0
10 MΩ	0	0	0	1

2.64 $\overline{\text{DATA INHIBIT}}$.

2.65 A contact-closure to common or a false logic level on this line (pin B9) inhibits the print command (J209, pin A11).

2.66 $\overline{\text{HOLD}}$.

2.67 This line duplicates the HOLD position of the PERIODIC/HOLD switch on the front panel when in remote operation. A contact-closure to common or a false logic level on this line (pin A10) "freezes" the data currently in the output storage latches. An updated reading will then occur on the next read command, either Direct Command or Delayed Command.

2.68 $\overline{\text{DIRECT COMMAND}}$.

2.69 With Hold mode selected (see $\overline{\text{HOLD}}$) a contact-closure to common or a false logic level on this line, pin A15, commands a new reading.

2.70 The Direct Command is used to generate a reading when no timeout signal is required (manual range). For readings requiring autorange, refer to $\overline{\text{DELAYED COMMAND}}$.

2.71 $\overline{\text{DELAYED COMMAND}}$.

2.72 In HOLD mode, a contact-closure to common or a false logic level applied to this line, pin B10, commands a new reading after a fixed delay period or "timeout" to allow for settling time of the input signal and relay operation. Timeouts for each function are listed in the command timing diagram, figure 2.9.

2.73 $\overline{\text{PROGRAM STORAGE}}$.

2.74 A switch-closure to common or a false logic level applied to this line, pin B15, stores the state of all program lines.

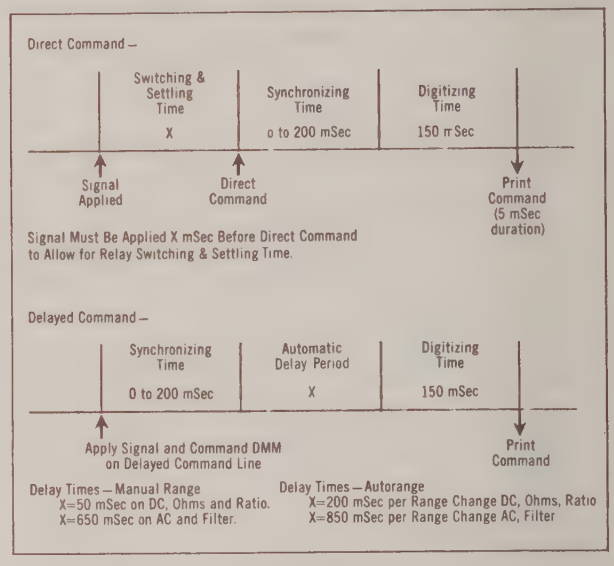

Direct Command –
Switching & Settling Time
X
Synchronizing Time
0 to 200 mSec
Digitizing Time
150 mSec
Signal Applied
Direct Command
Print Command (5 mSec duration)
Signal Must Be Applied X mSec Before Direct Command to Allow for Relay Switching & Settling Time.
Delayed Command –
Synchronizing Time
0 to 200 mSec
Automatic Delay Period
X
Digitizing Time
150 mSec
Apply Signal and Command DMM on Delayed Command Line
Print Command
Delay Times – Manual Range
X=50 mSec on DC, Ohms and Ratio.
X=650 mSec on AC and Filter.
Delay Times – Autorange
X=200 mSec per Range Change DC, Ohms, Ratio
X=850 mSec per Range Change AC, Filter

Figure 2.9 - Command Timing

2.75 ADDING/REMOVING ACCESSORIES.

2.76 The AC converter may be installed or removed in the field without affecting the operation of any other function in the instrument. The addition or removal of the Ohms converter, however, requires the removal or addition of a jumper to the back side of the Main Logic board.

2.77 Instruments shipped from the factory without an Ohms converter are provided with a jumper wire (designated W4) connected between terminals 5 and 6 of relay K2 (W4 is shown in figure 6.2). This jumper must be removed whenever an Ohms converter is added to the instrument and must be installed whenever the instrument is operated without the Ohms converter.

SECTION 3 SPECIFICATION TESTS

3.1 GENERAL.

3.2 This procedure is designed to insure that the instrument is operating properly and within its specifications. If any of the readings are not within tolerance, refer to the calibration procedure. If the instrument fails to operate properly, refer to the troubleshooting procedure.

3.3 PREPARATION.

3.4 Allow one hour warmup time for the instrument to reach full accuracy.

3.5 EQUIPMENT.

3.6 A list of equipment is provided in table 3.1.

3.7 PROCEDURE.

3.8 Connect the DVM and test equipment as shown in the figure supplied with each accuracy check. Select the controls and inputs as called out in the tables and monitor the DVM readout for the indicated values.

Table 3.1 - Required Equipment

TYPE	REQUIRED SPECS	SUGGESTED EQUIPMENT
DC Voltage Standard	Adjustable: 0 to 1000V RMS Resolution: 1 μV on 10V range Accuracy: ± .003%	Fluke 332A
Decade Voltage Divider	.005% Accuracy	ESI Model RV622A
AC Laboratory power source	Variable: 0 to 500V RMS & 20 Hz to 100 KHz. Resolution better than 100 PPM. Harmonic distortion of 0.1% or less. Stability of .01%	HP 745/746
Thermal Transfer voltmeter [1]	AC/DC thermal transfer voltmeter. Ranges: 1 to 500V. Accuracy 0.05% or better	Holt Model 6 Thermal Transfer Voltmeter
Standard Resistors [2]	1, 10 Megohms; 1, 10, 100 Kohm; 100 Ohm. All ±.001% except 10 Megohm which is ±.005%.	ESI SR-1 series standard resistors
1/4W Carbon Resistors	10, 100 Kohm and 100 Ohm	
Capacitor	1 μF (non polar)	
Batteries, 2 required	1.5V cells having screw type binding posts	

[1] Required for instruments equipped with AC Option only

[2] Required for instruments equipped with OHMS Option only

Table 3.2 - DC Range Check (Low Ranges)

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD	DIVIDER SETTING			
DC	.1V	10.00000	.01000	.100000	.099985 – .100015	23°C ± 5°C (After zeroing)
	1V	10.00000	.10000	1.00000	0.99988 – 1.00012	

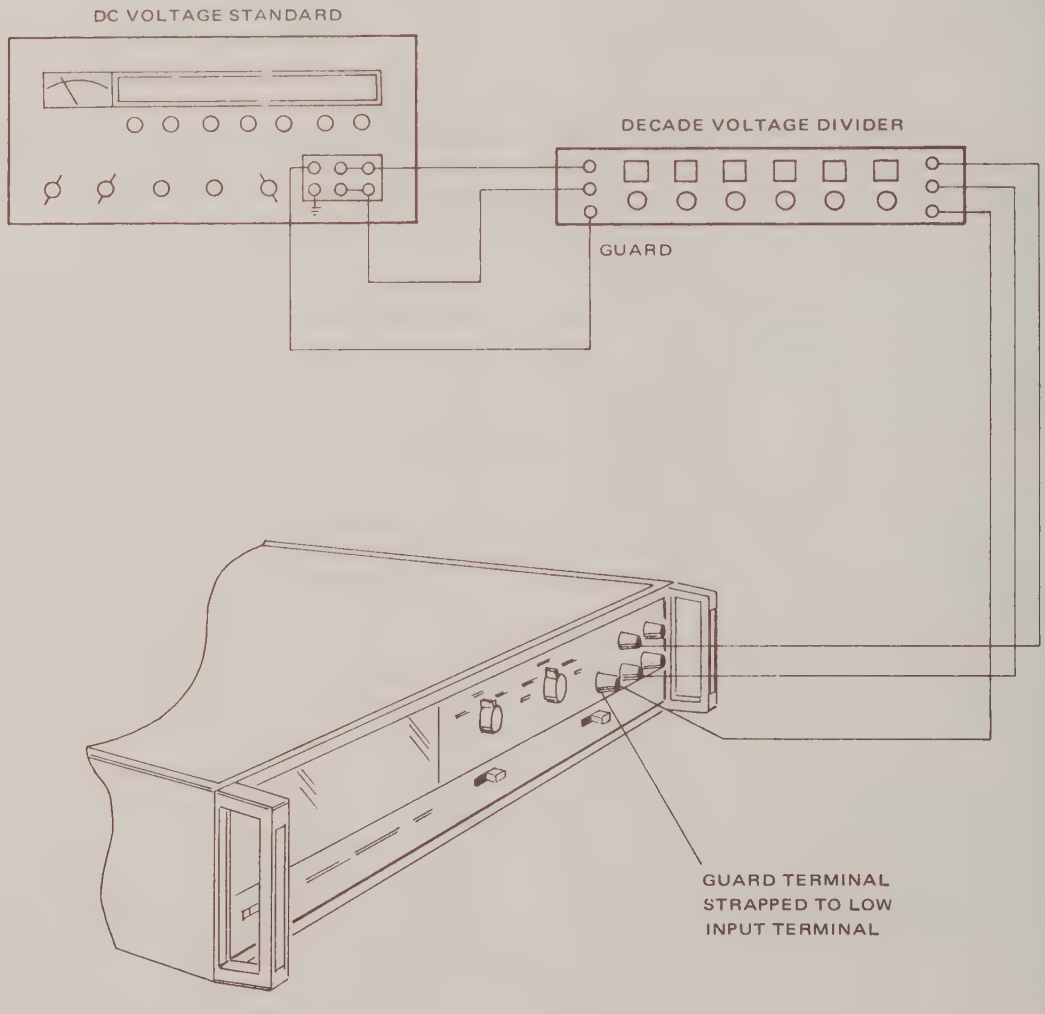


Table 3.3 - DC Range Check (High Ranges)

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD				
DC	10	10.0000V		10.0000	9.9988 – 10.0012	$23^{o}C \pm 5^{o}C$ (After zeroing)
	100	100.000V		100.000	99.988 – 100.012	
	1000	1000.00V		1000.00	999.88 – 1000.12	

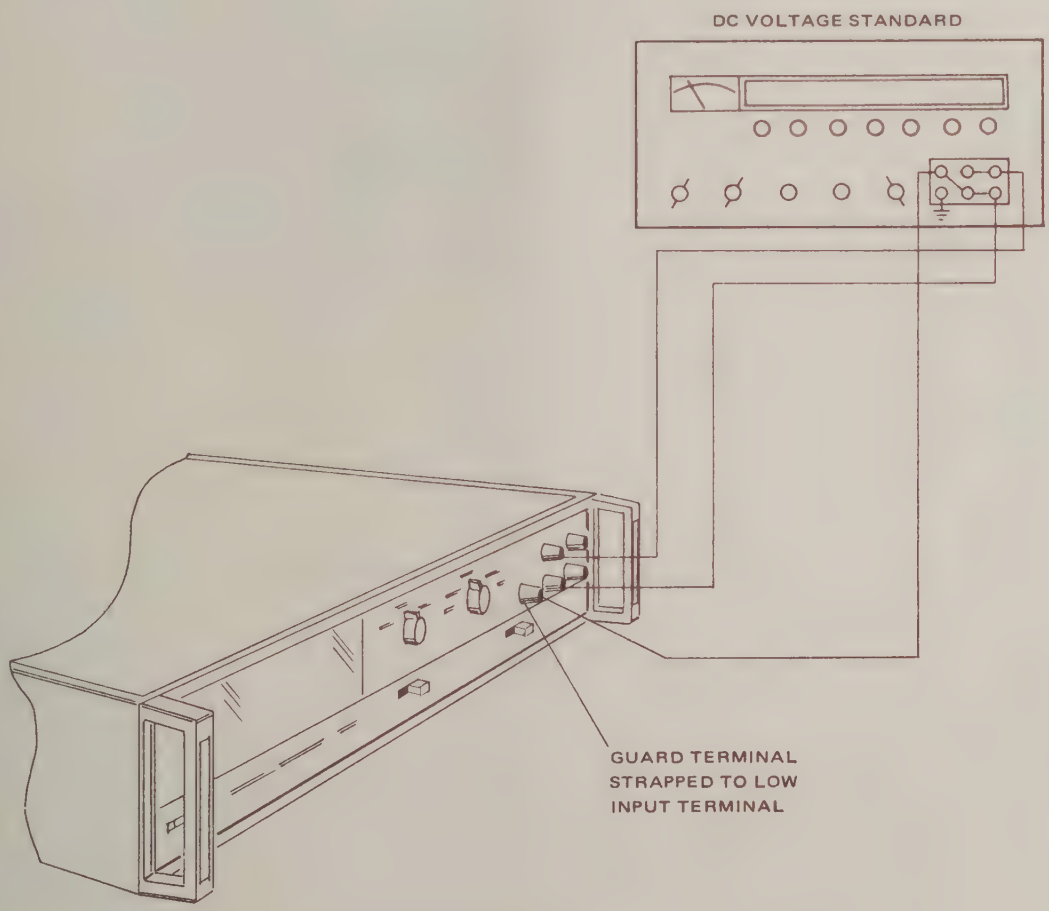


Table 3.4 - Ratio Check

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD				
DC	10	+ 2.00000V		+10.0000	9.9940 – 10.0060	23°C ± 5°C (After zeroing)
RATIO X10	10	+10.00000V		+10.0000	9.9988 – 10.0012	
		–10.00000V		+10.0000	9.9988 – 10.0012	

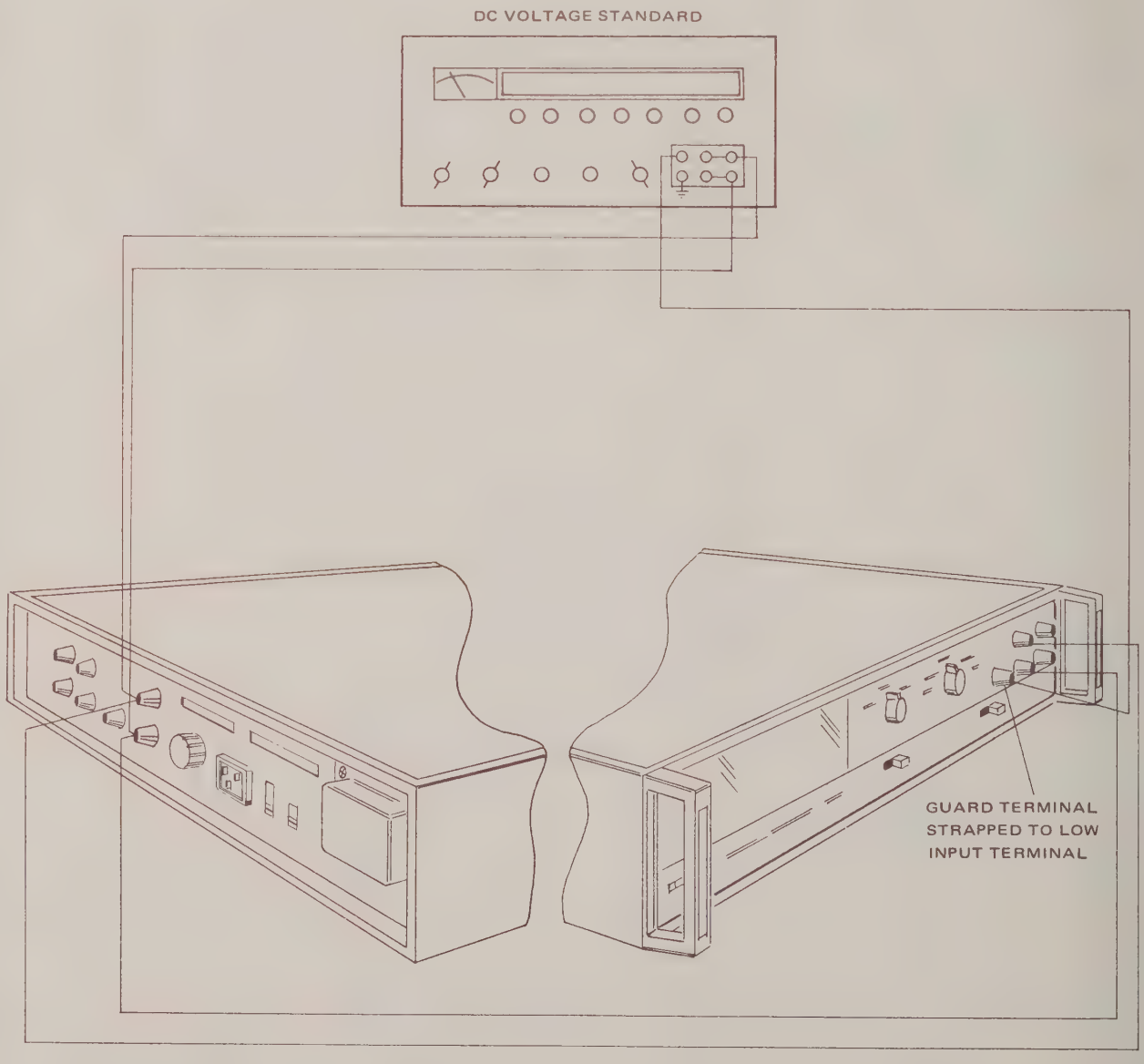


Table 3.5 - DC Input Resistance

DVM		INPUT SIGNAL		DVM DISPLAY	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTS*	S1			
DC	0.1	.100000	Closed	.10000		Rs
			Open		.099990 – .100010	10K
	1	1.000000	Closed	1.0000		
			Open		0.99990 – 1.00010	100K
	10	10.00000	Closed	10.000		
			Open		9.9990 – 10.0010	100Ω
	100	100.0000	Closed	100.00		
			Open		99.990 – 100.010	100Ω
	1000	1000.000	Closed	1000.0		
			Open		999.90 – 1000.10	100Ω
						*Adjust the DC Voltage Standard to produce the DVM DISPLAY reading.

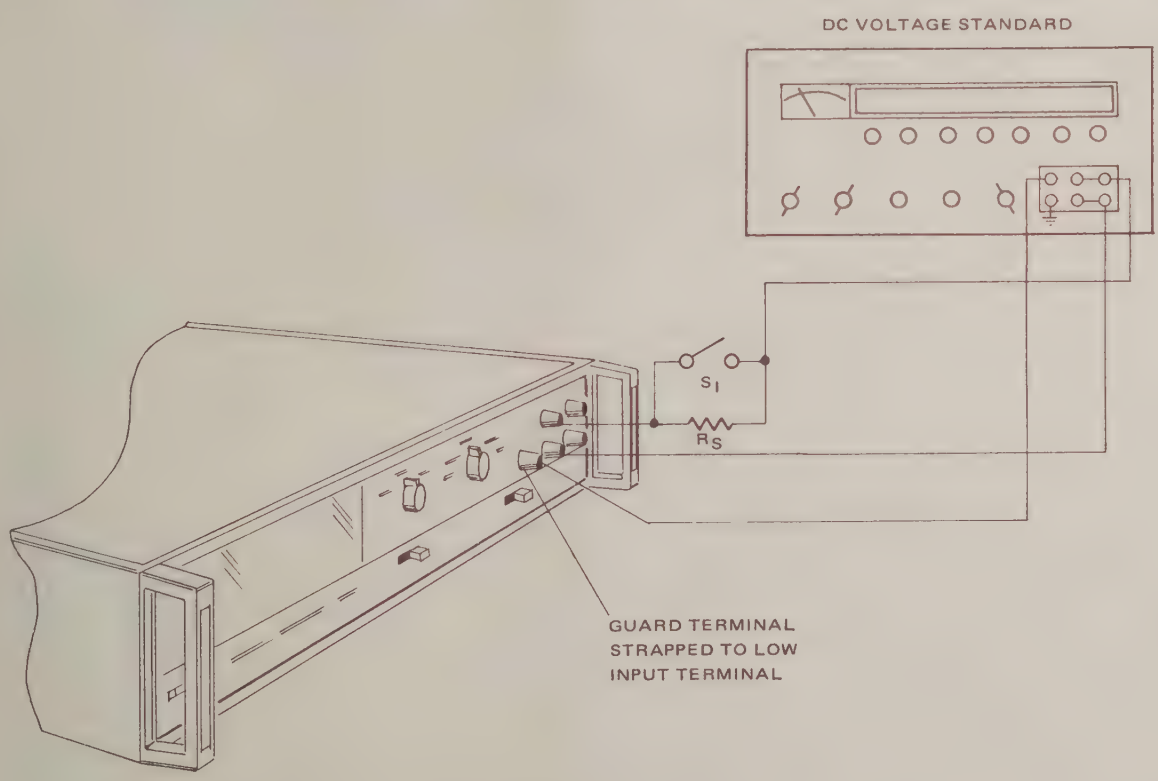


Table 3.6 - AC Range Check

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD	AC			
AC	1	1.000000	1.V, 10 KHz	1.00000	0.99880 – 1.00120	Set thermal transfer voltmeter to same range as the DMM Adjust the amplitude controls on the AC source to produce a Null on the thermal transfer Voltmeter, for each new setting 23°C ± 5°C
		1.000000	1.V, 50 KHz	1.00000	0.99830 – 1.00170	
	10	10.00000	10V, 10 KHz	10.0000	9.9880 – 10.0120	
		10.00000	10V, 50 KHz	10.0000	9.9830 – 10.0170	
	100	100.0000	100V, 10 KHz	100.000	99.880 – 100.120	
		100.0000	100V, 50 KHz	100.000	99.830 – 100.170	
	1000	125.0000	125V, 10 KHz	125.00	124.67 – 125.33	
		125.0000	125V, 50 KHz	125.00	124.61 – 125.39	

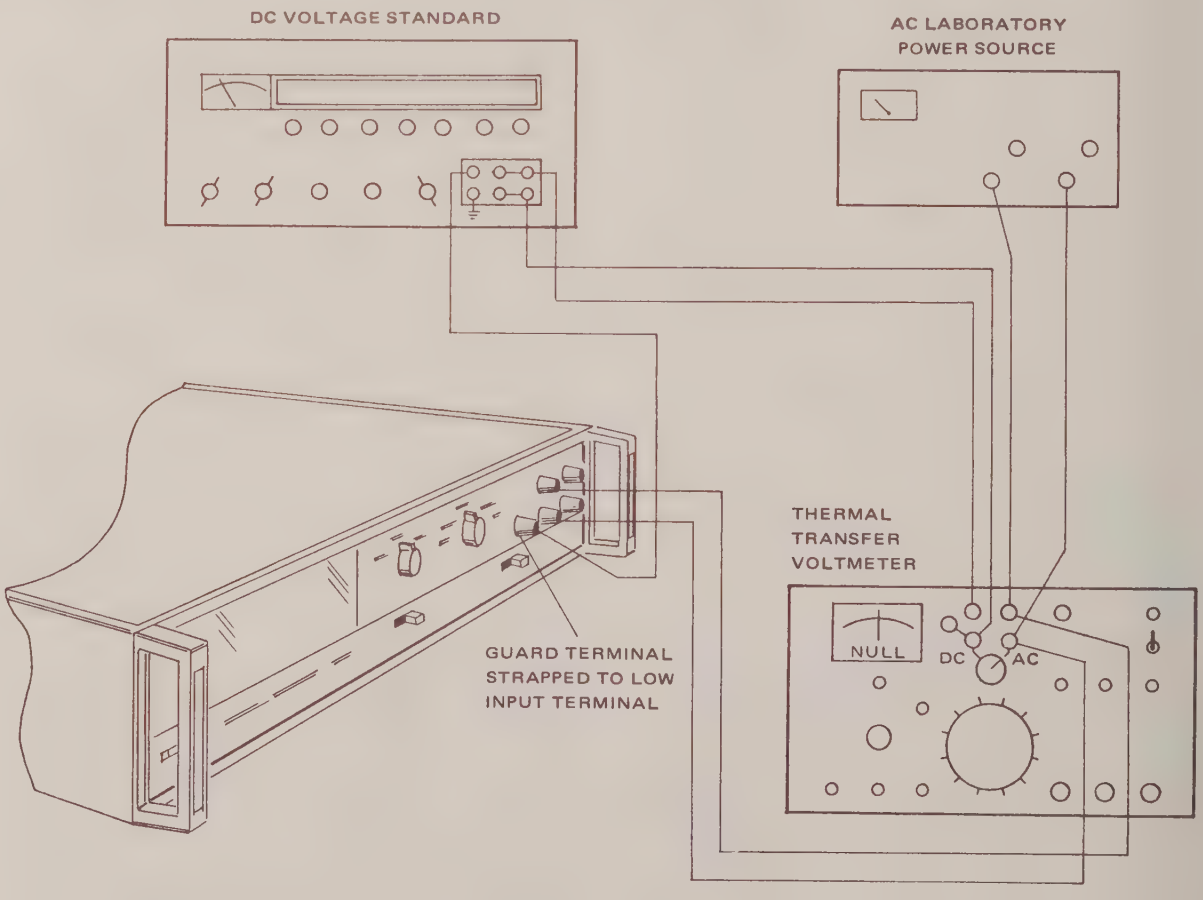


Table 3.7 - Ohms-Megohms Range Check

DVM		INPUT SIGNAL		NOMINAL READING (Same as Standard)	TOLERANCE
FUNCTION	RANGE	NOMINAL STANDARD VALUE	TOLERANCE		
KΩ	.1 KΩ	100Ω	.001%		±25 digits
	1 KΩ	1 KΩ	.001%		±12 digits
	10 KΩ	10 KΩ	.001%		±12 digits
	100 KΩ	100 KΩ	.001%		±12 digits
	1000 KΩ	1 MΩ	.001%		±22 digits
	10,000 KΩ	10 MΩ	.005%		±32 digits

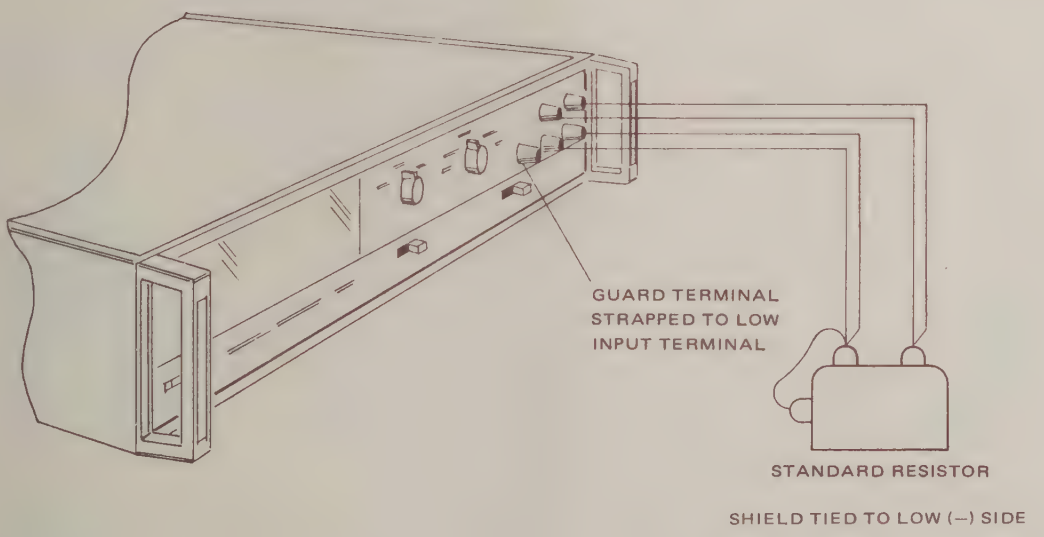


Table 3.8 - Common Mode Rejection (In DC Volts Function)

DVM		INPUT SIGNAL		NOMINAL READING See Note 1	TOLERANCE	NOTE
FUNCTION	RANGE	S1				
DCV FILT. OUT	0.1	Off			±1 digit from nominal	1) With switch S-1 in the off position, record the reading displayed on the DMM's readout in the "nominal reading" boxes of the table.
		DC			±50 digits from nominal	
		AC			±25 digits from nominal	
DCV FILT. IN	0.1	DC			±50 digits from nominal	
		AC			±25 digits from nominal	

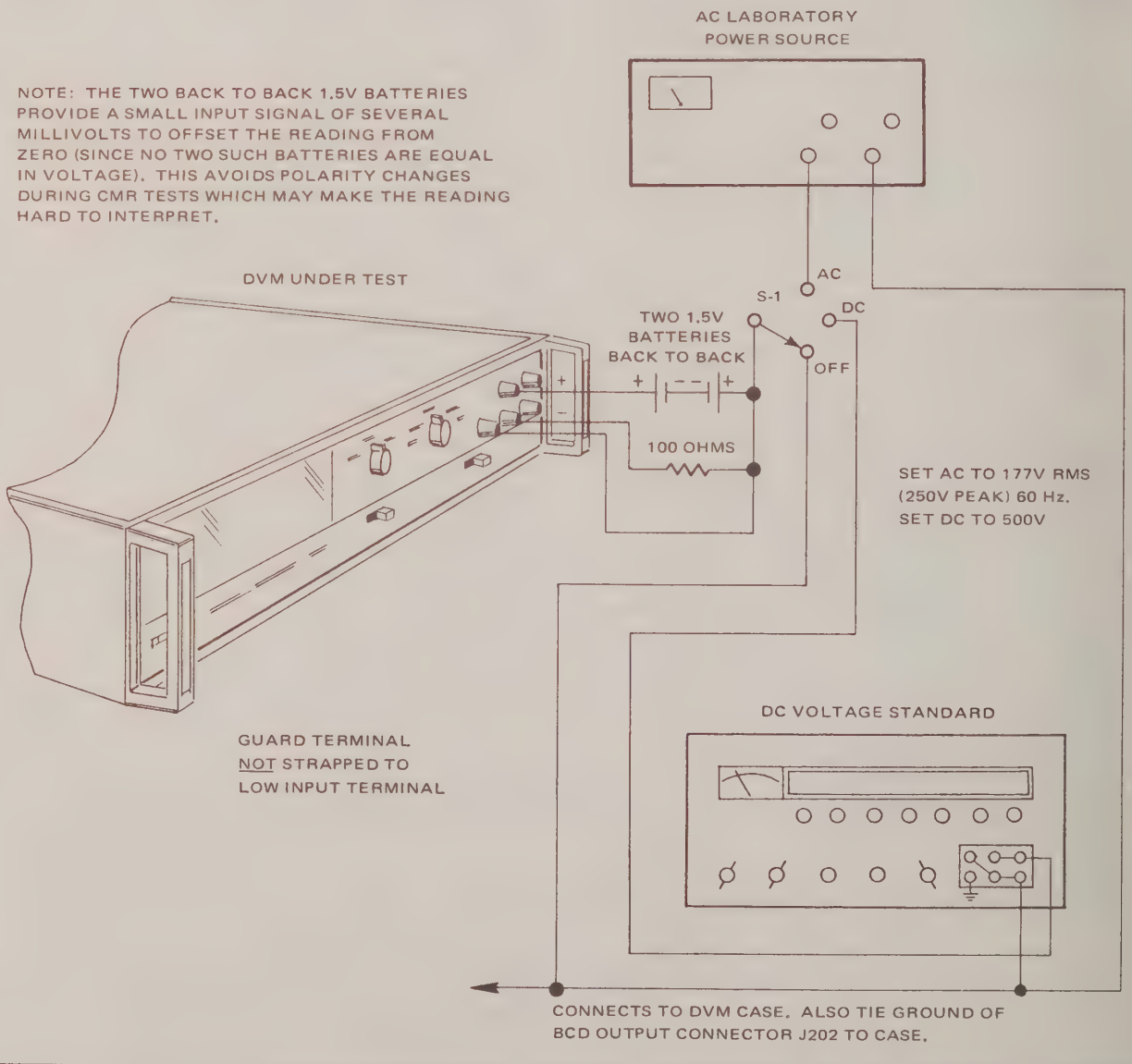

AC LABORATORY POWER SOURCE
NOTE: THE TWO BACK TO BACK 1.5V BATTERIES PROVIDE A SMALL INPUT SIGNAL OF SEVERAL MILLIVOLTS TO OFFSET THE READING FROM ZERO (SINCE NO TWO SUCH BATTERIES ARE EQUAL IN VOLTAGE). THIS AVOIDS POLARITY CHANGES DURING CMR TESTS WHICH MAY MAKE THE READING HARD TO INTERPRET.
DVM UNDER TEST
AC
S-1
DC
TWO 1.5V BATTERIES BACK TO BACK
OFF
100 OHMS
SET AC TO 177V RMS (250V PEAK) 60 Hz. SET DC TO 500V
DC VOLTAGE STANDARD
GUARD TERMINAL NOT STRAPPED TO LOW INPUT TERMINAL
CONNECTS TO DVM CASE. ALSO TIE GROUND OF BCD OUTPUT CONNECTOR J202 TO CASE.

Table 3.9 - Normal Mode Noise Rejection (In DC Volts Function)

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC	AC			
DC FILT. OUT	10	0.5V	10V , 60 Hz	00.5000	±200 digits	
	1	0.5V	1V*, 60 Hz, ±.1%	0.50000	±200 digits	
FILT. IN	10	0.5V	10V*, 60 Hz	00.5000	±10 digits	
	1	0.5V	10V*, 60 Hz	0.50000	±100 digits	

*peak

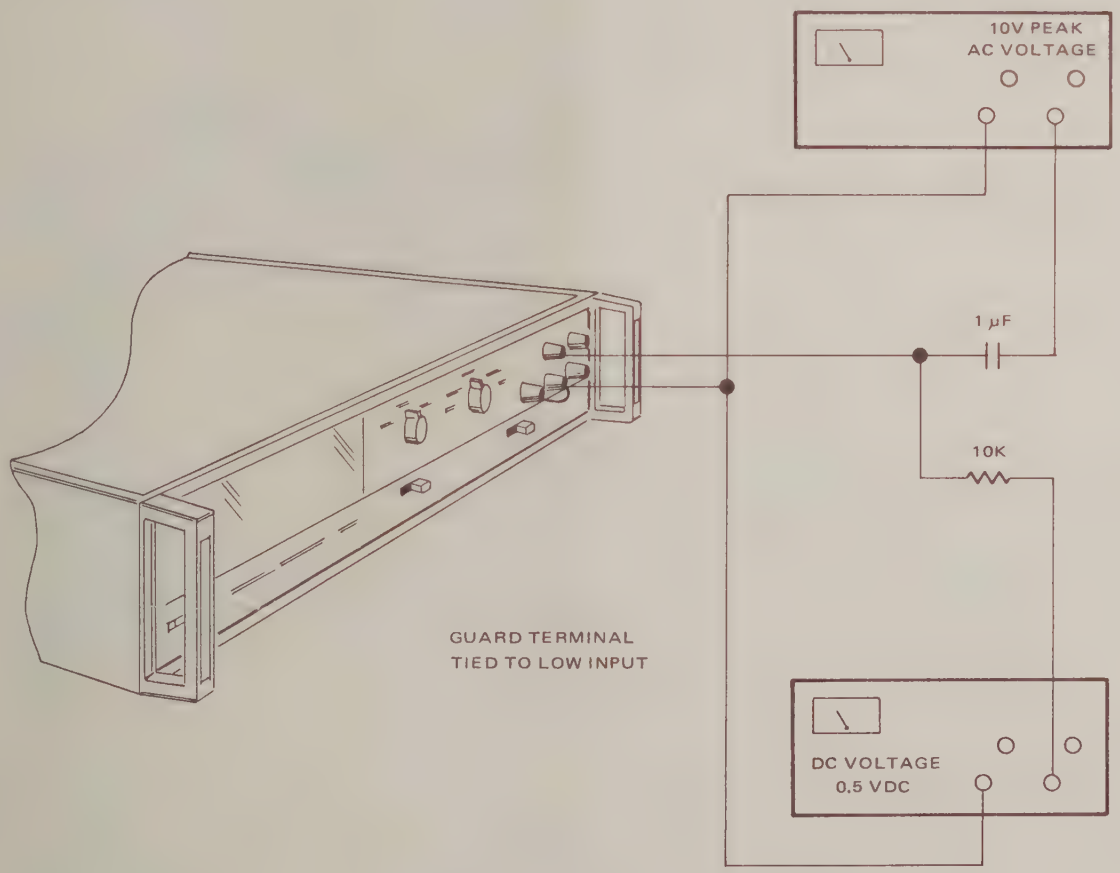
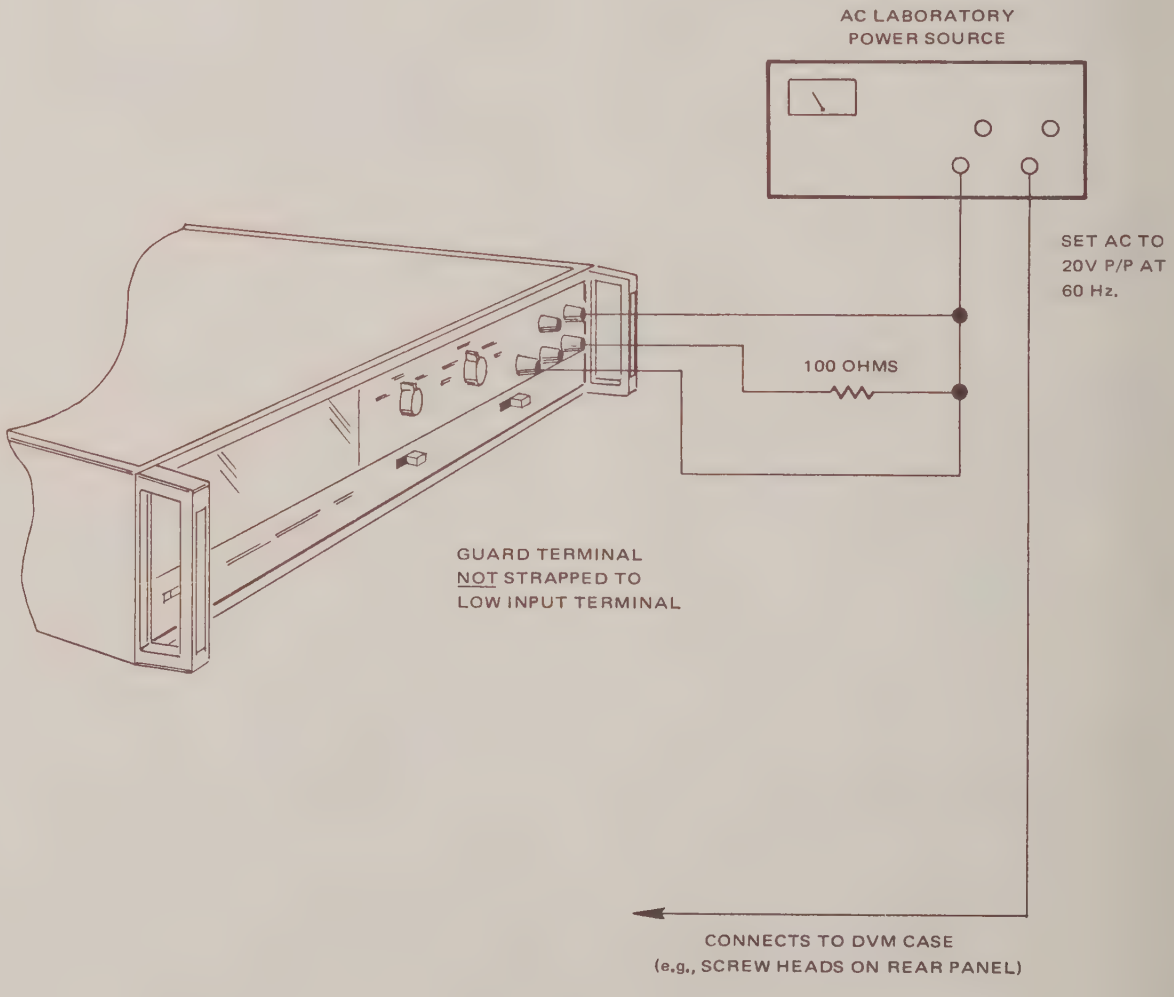


Table 3.10 - Common Mode Rejection (In AC Volts Function)

DVM		COMMON MODE INPUT SIGNAL		NOMINAL READING (see note)	TOLERANCE	NOTE
FUNCTION	RANGE	VOLTAGE	FREQ.			
AC	1	20V P.P.	60 Hz		±100 digits	Enter reading with shorted input in nominal column before beginning
	10	20V P.P.	60 Hz		±10 digits	
	100	20V P.P.	60 Hz		±1 digit	
	1000	20V P.P.	60 Hz		±1 digit	



SECTION 4 THEORY OF OPERATION

4.1 GENERAL.

4.2 This section describes the operation of the main circuits in the Model 5000 DMM, shown simplified in the block diagram of figure 4.1. Drawings included are provided as a supplement to the complete drawings found in Section 6.

4.3 SIGNAL CONDITIONING.

4.4 The signal conditioning circuitry routes, scales, converts, amplifies, and filters the input signal to provide a five volts output (with full-scale input) for use by the converting circuitry.

4.5 DC Measurement.

4.6 With the DC function selected, the dc signal at the input terminals is routed directly to the dc attenuator. No attenuation is required on the 0.1 and 1 volt ranges; the signal passes through the 100K series resistor to the isolator input. Attenuation factors of 1/2, 1/100, and 1/1000 are used on the 10, 100, and 1000 volt ranges respectively with the output then being routed to the isolator input.

4.7 Isolator.

4.8 The isolator, shown simplified in figure 4.2, is a potentiometric amplifier with selectable gains of 1, 5, and 50. An integral bootstrap amplifier increases the apparent input impedance of the amplifier to over 1000 megohms. The input of the amplifier is clamp protected against input signals greater than ±13 volts. Filtering is single pole, R-C type with filter selected shunts of .02, and .5 μF depending on function available and range selected.

4.9 AC Converter.

4.10 Two AC converters are available for use in the Model 5000; the Model 34 Averaging converter and the Model 44 RMS converter. Each converter is mounted on a single printed circuit board and occupies connectors J1 and J2 on the 5000 circuit board. The converters accept AC inputs on the 1, 10, 100, and 1000 volt ranges, then scales and rectifies these signals to produce a dc level representative of the input. With AC function selected, the ac input signal is routed from the input terminal to pin 2 of J1 (the remaining five pins of J1 are used as a shield); the resultant dc output from pin 2 of J2 (+1 volt for a full-scale input) is routed to the isolator.

4.11 AC CONVERTER, AVERAGING.

4.12 The averaging converter shown simplified in figure 4.3, consists of an active rectifier/range circuit, a filter, and an output amplifier. The active rectifier is an operational amplifier with two polarity sensitive feedback paths; the feedback path consisting of CR3 and R29 conducts current when the output of the amplifier is positive and the CR4, R28 path conducts when the amplifier output is negative. The two currents are recombined across resistor R30, and the resulting ac signal is fed through the range feedback network to the input summing node of the operational amplifier. Two half-wave signals of opposite polarities are developed across resistors R28 and R29 for each full-wave input. These signals are filtered and amplified as a dc level by the differential output amplifier.

4.13 Feedback on the 1 volt range is through a permanently connected feedback path; the 10, 100, and 1000 ranges have relay selected feedback paths that parallel the 1 volt network.

4.14 AC CONVERTER, RMS.

4.15 The RMS converter shown simplified in figure 4.4 consists of a scaling amplifier, active rectifier, log amplifier, output amplifier, and a filter-attenuator network. The scaling amplifier provides a 1 volt output for a full-scale input on each range. The active rectifier converts the output of the scaling amplifier to a positive halfwave signal that is fed through a 10K resistor to the summing node of the log amplifier input. A full wave signal from the scaling amplifier output is also supplied through a 20K resistor to the summing node of the log amplifier resulting in a full wave rectified current flowing through the log amplifier feedback loop consisting of Q7A and Q5A. The feedback path is non-linear and the voltage developed across Q5A and Q7A is proportional to the log of the rectified signal current.

4.16 The output of the log amplifier also drives an input network that is identical to the log amplifier feedback consisting of Q5B and Q7B. This input network supplies current to the summing node of the output amplifier and converts the log amplifier output to an RMS current with the ac component bypassed through C20 and the dc component flowing through the collector of Q7B. This current is converted to a 5 volt RMS voltage (for a full-scale input) at the output of the output amplifier, filtered and attenuated to produce a 1 volt full-scale level for use by the DVM measurement circuitry.

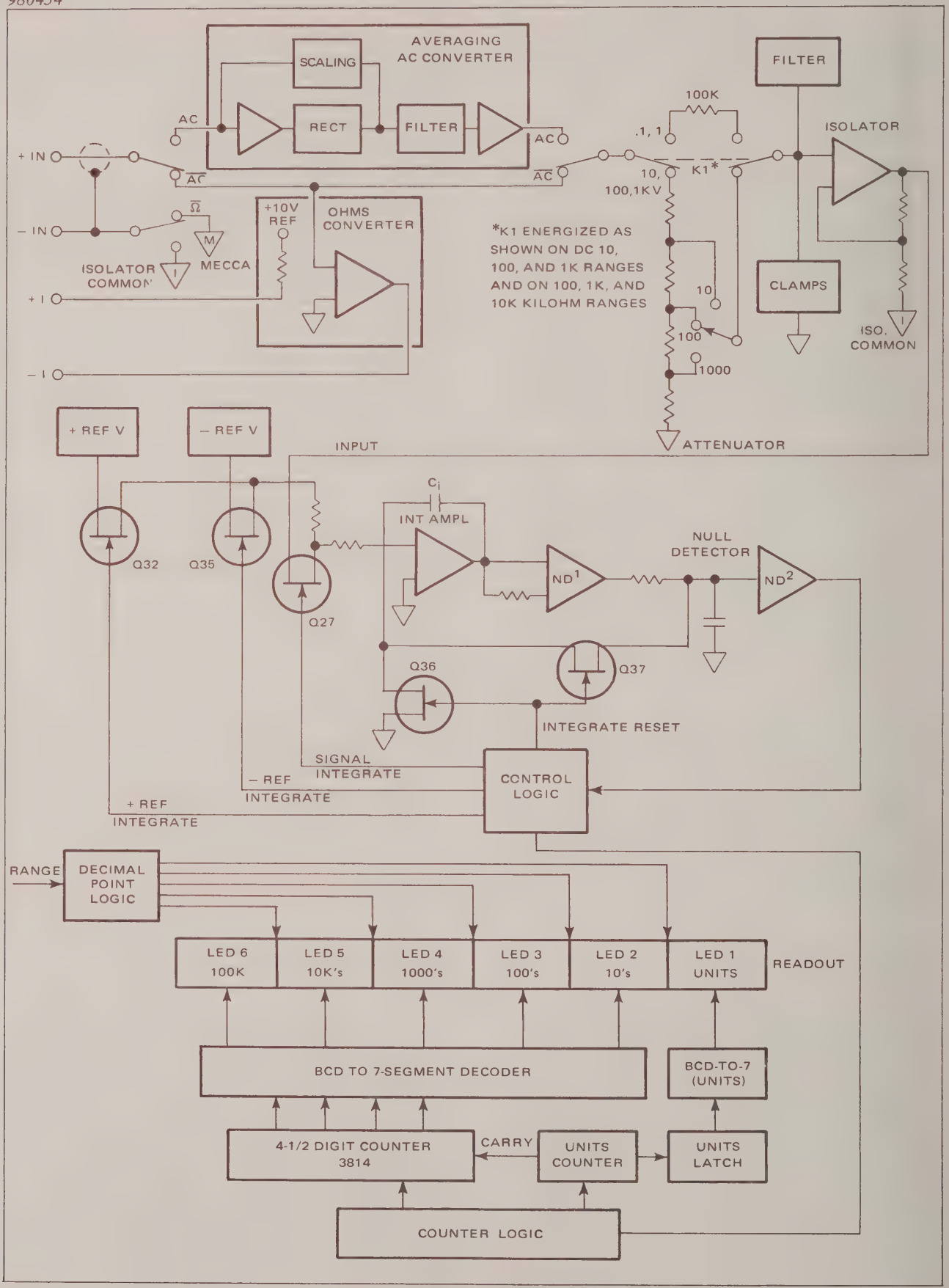


Figure 4.1 - 5000 Block Diagram

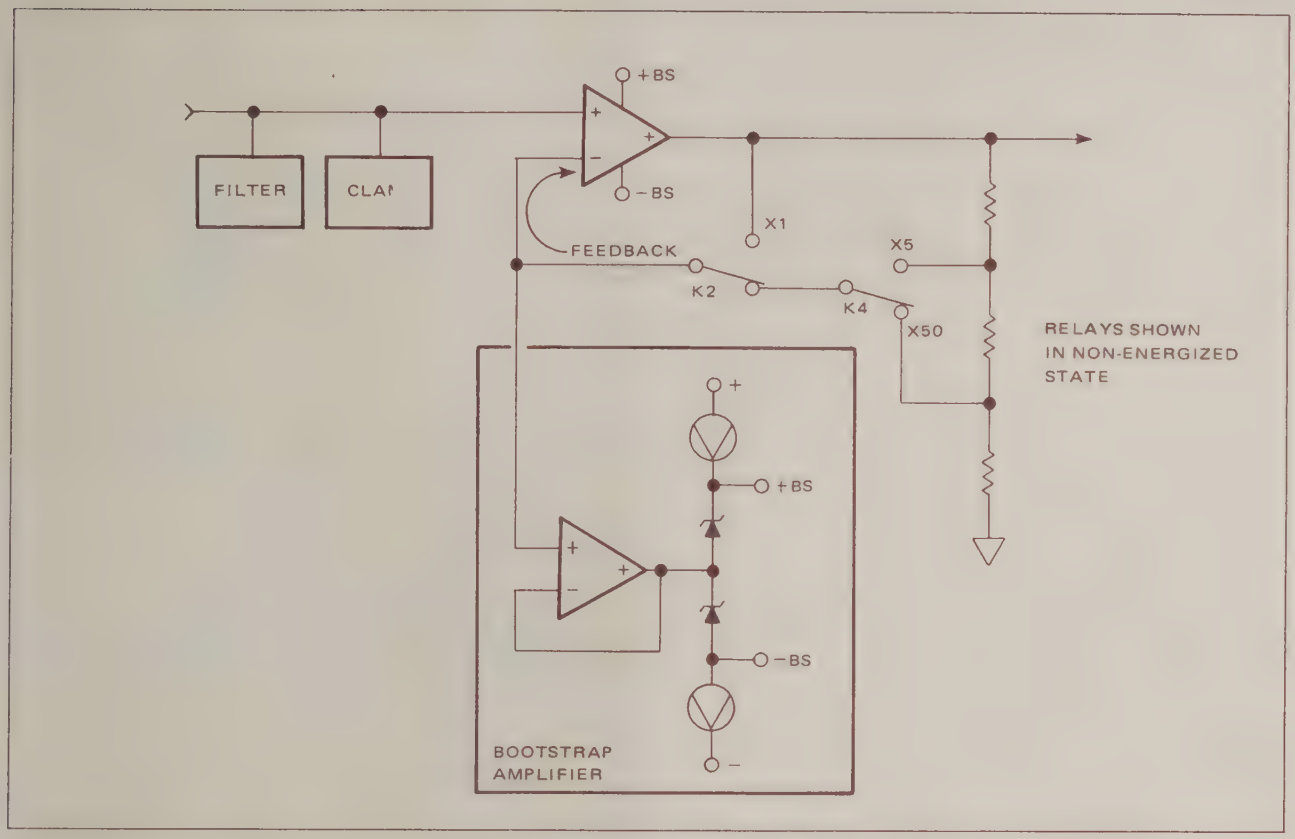


Figure 4.2 - Isolator

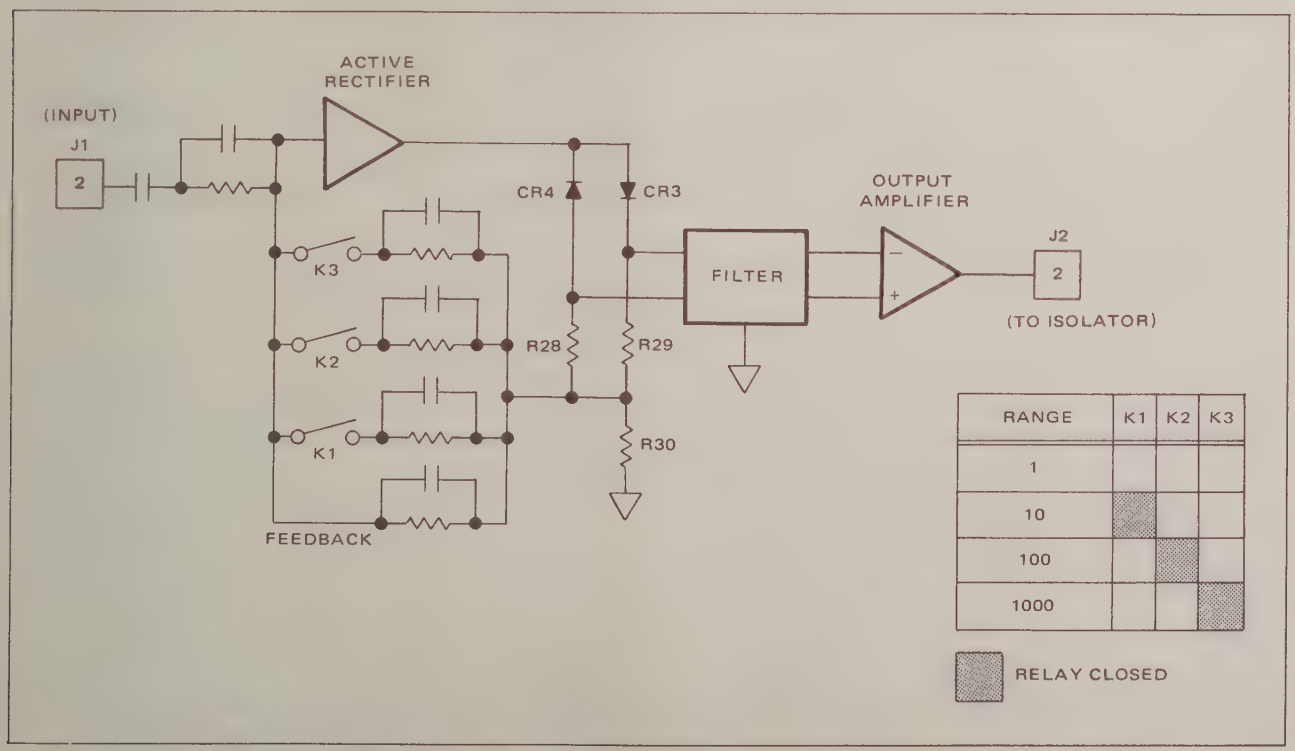


Figure 4.3 - Averaging AC Converter

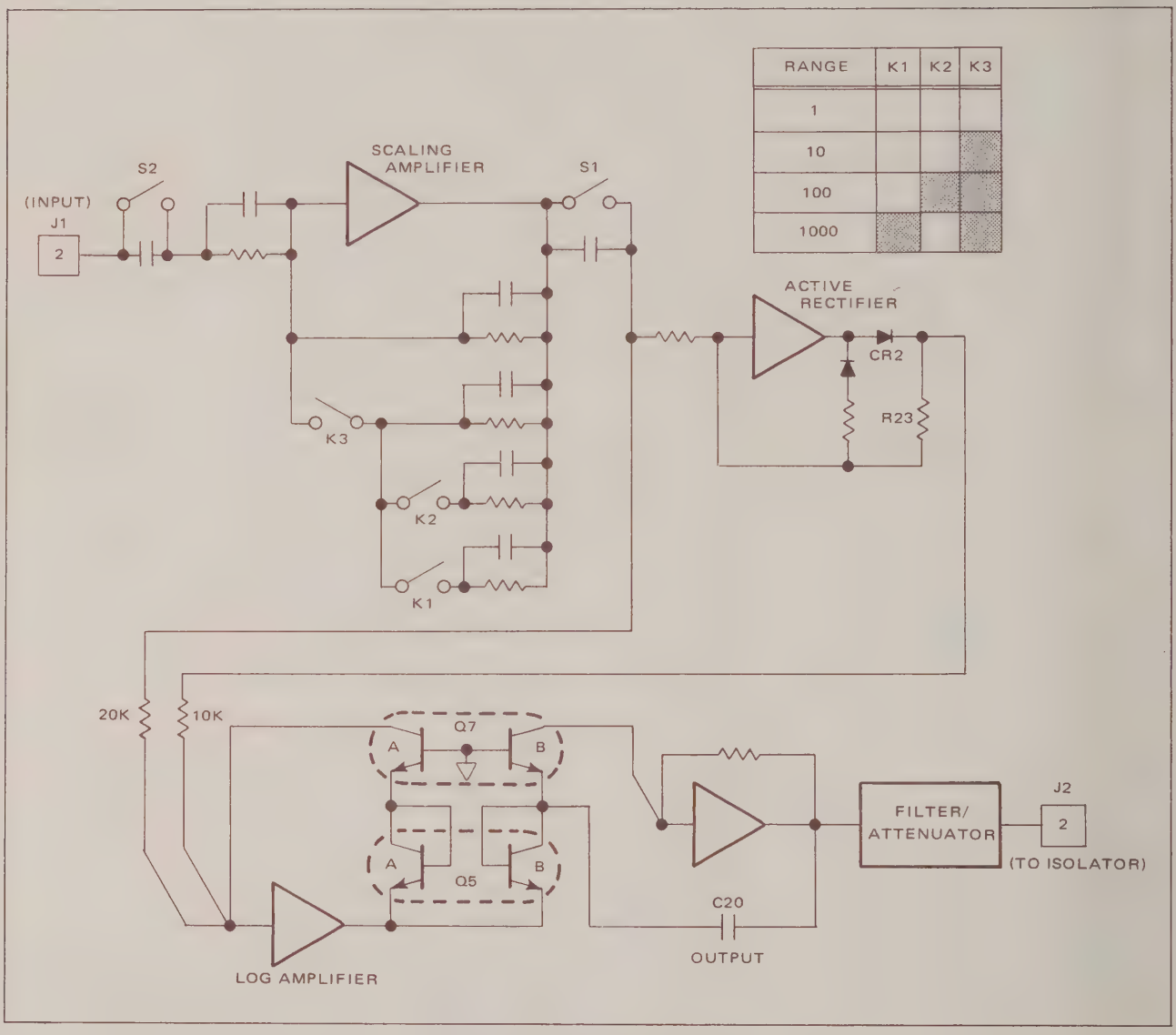


Figure 4.4 - RMS AC Converter

4.17 Ohms Converter.

4.18 In the ohms function, the ohms converter generates a fixed and stable current for each range selected. The current is fed through the resistance to be measured and, in the process, develops a d.c. voltage across the resistor that is dependent on the value of the resistance. This voltage is measured by the DVM and displayed. The current supplied provides a full-scale DVM reading when the resistance being measured is equal to the range selected (e.g., measuring 10 kilohms on the 10K range produces a DVM readout of 10:0000).

4.19 The ohms converter, shown in figure 4.5, consists of a relay controlled current source, an operational amplifier (ohms converter) and a current compensation circuit. The current source consists of precision resistors connected between the +10 volt reference and, by way of the +I and +IN terminals on the front panel, the summing node of the ohms converter amplifier. The current source generates a current equal to 10 volts divided by the source resistor. An equal amount of current flows from the summing node, through the resistor being measured (R_X) and to the output of the ohms converter. The current compensation circuit is used on the three lower ohms ranges to eliminate any current errors that might occur due to resistance in the –IN lead.

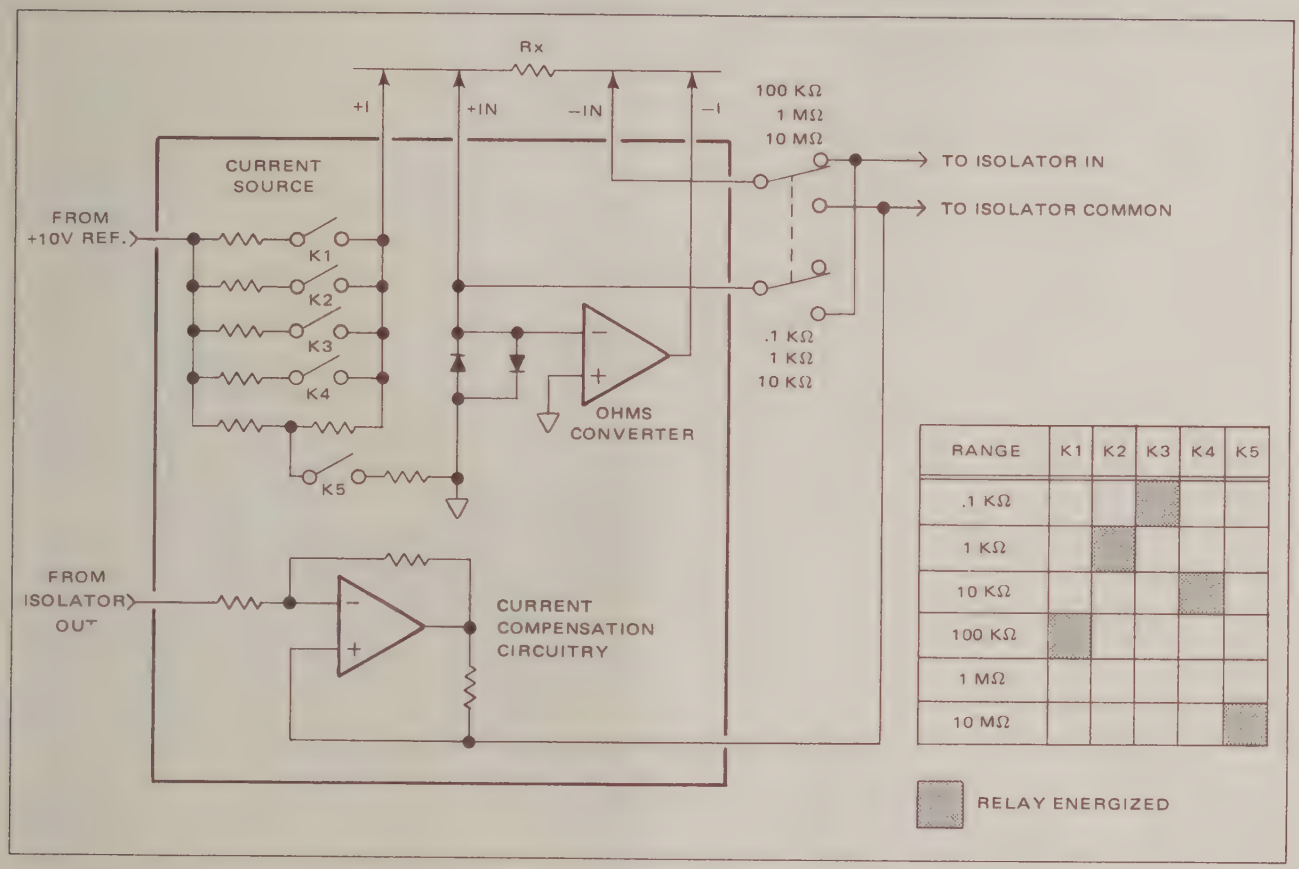


Figure 4.5 - Ohms Converter

4.20 ANALOG-TO-DIGITAL CONVERSION.

4.21 The conversion used in the Model 5000 is an improved version of the basic dual-slope method and is called delayed dual-slope integration. The circuitry used to perform the conversion is shown simplified in figure 4.6 along with the timing of the various control inputs. In this method, the conditioned five volt full-scale output of the isolator is applied to the integrator for a period of 50 milliseconds to develop a potential, proportional to the input signal. A 10 volt reference voltage of the opposite polarity is applied to the integrator; the time required to discharge the integrator is a direct function of the input voltage and is measured and displayed by the digital circuitry. The basic circuitry modification is the addition of an R-C filter between the integrator and null detector circuits. This greatly improves the noise immunity characteristics of the null detector especially with inputs near zero volts. The R-C circuit causes a delay or time shift which requires both a 100 count delay in the counter circuitry and a 5 millivolt analog offset (this offset is provided by the delay compensation circuitry preceding the gain stage).

4.22 Digital Circuitry.

4.23 The heart of the digital circuitry is the 3814 Digital Voltmeter logic array, shown in figure 4.7. It contains four full decade counters, two overflow latches, an underrange output, an overrange output, outputs to drive a BCD to seven segment display devise, and five decoded outputs to strobe the display.

4.24 Because the 5000 DMM is a five digit instrument with an overrange digit, an extra decade counter is used for the units digit of the display. The 3814 is responsible for the next four full digits and the overrange digit. The 2 MHz clock is used to drive U3, a SN7490 decade counter. The output of U3 is inverted by U10 and drives the clock pulse 200 kHz (CP) input to U6, the 3814 digital voltmeter logic array. The decade counters change state on the rising edge of the clock pulse.

4.25 The output of the second decade is gated with the clock pulse to provide a divide-by-one thousand (÷1000) output. This clock pulse (2 kHz) is used to drive the step

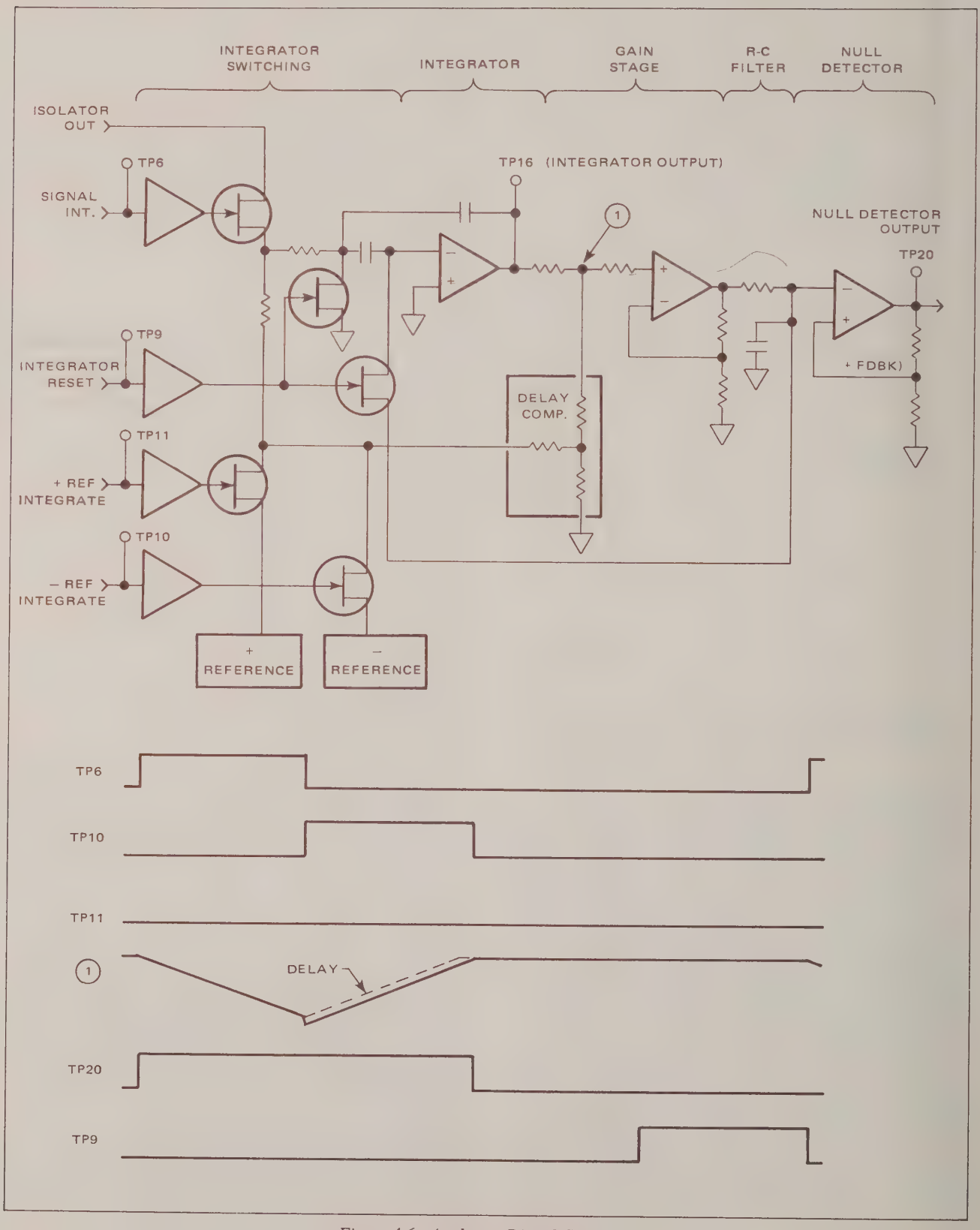


Figure 4.6 - Analog-to-Digital Conversion

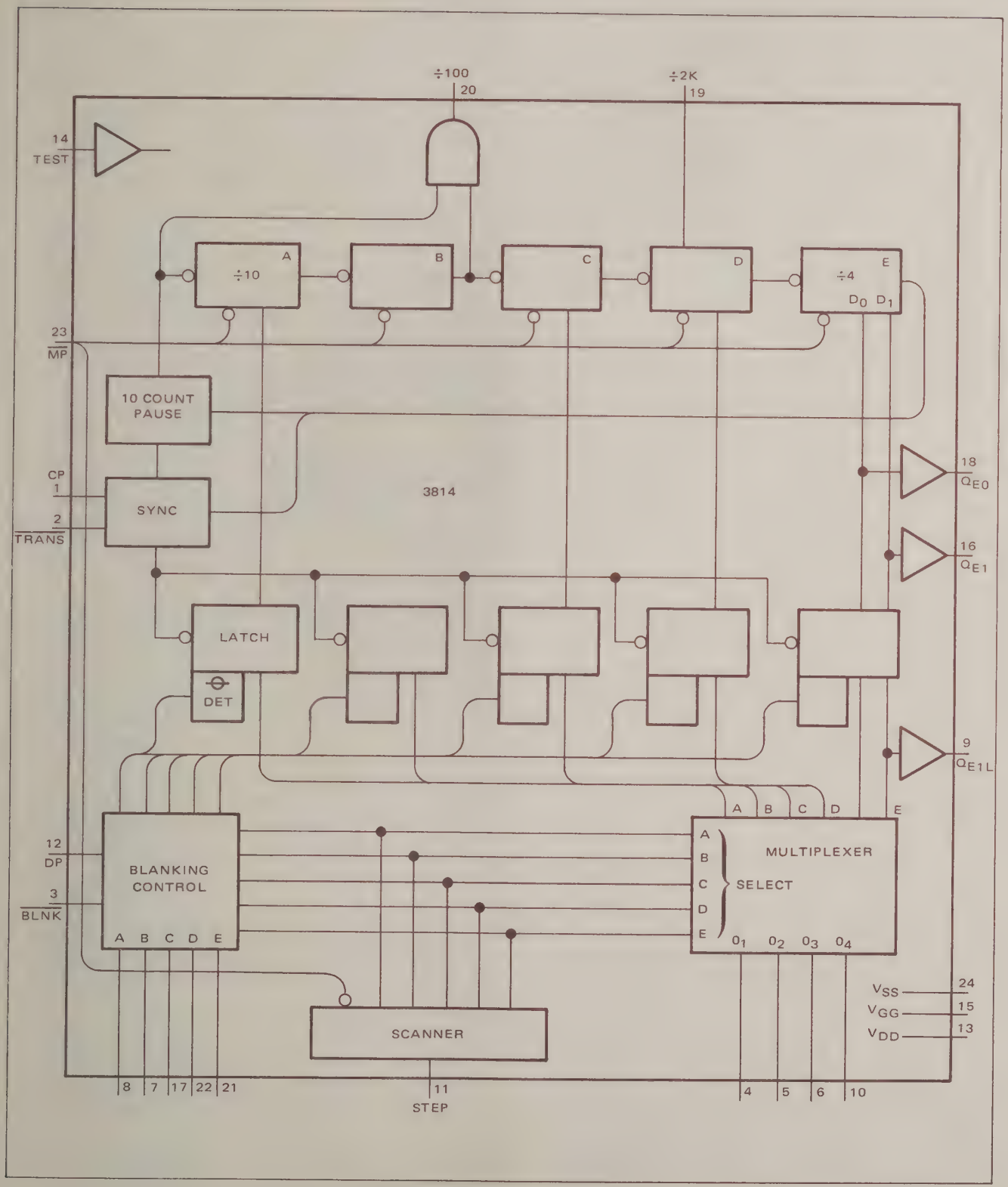
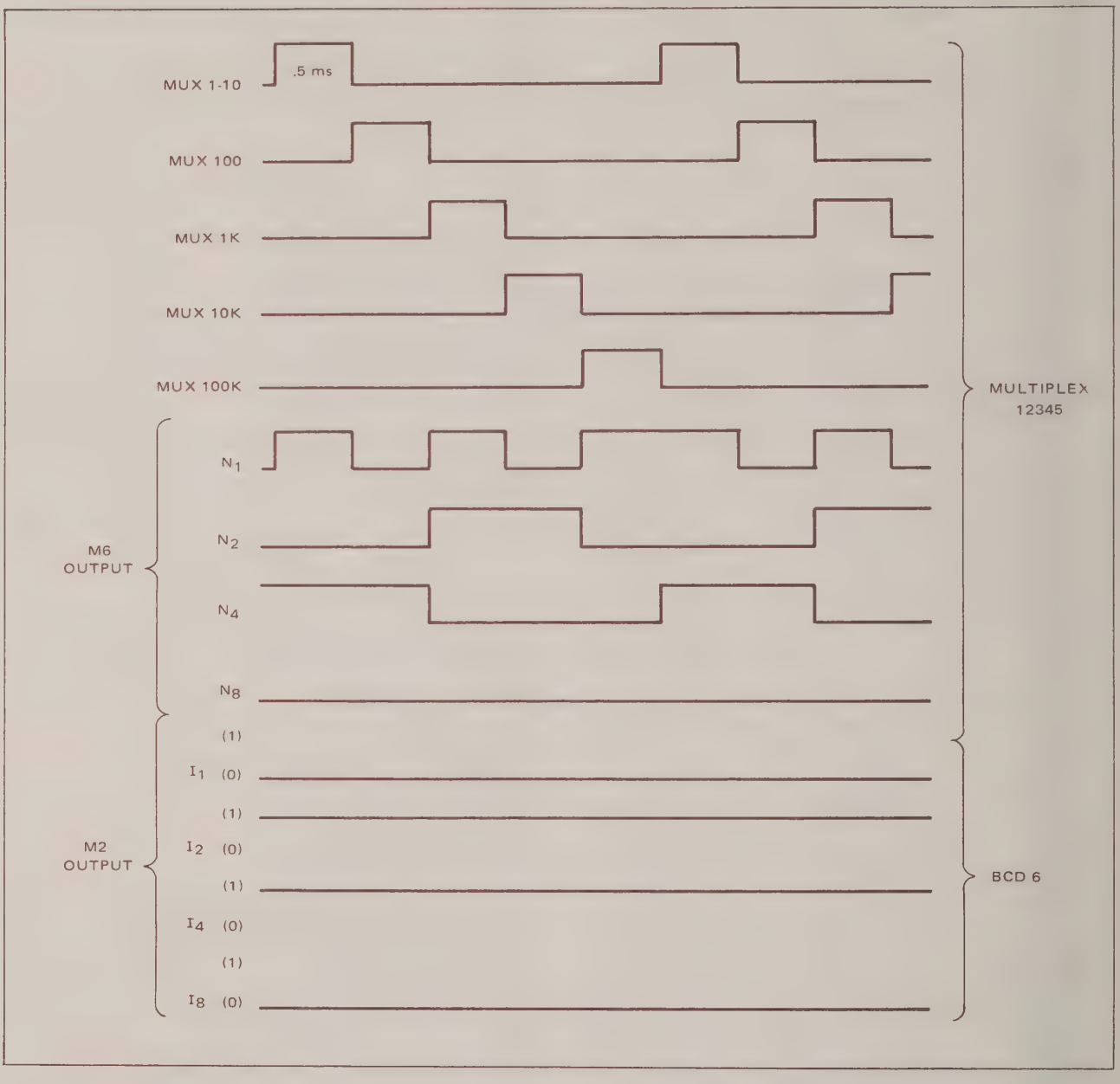


Figure 4.7 - Logic Array

Table 4.1 - Display Logic Sequence



input of the 3814 and a synchronous timing pulse for the data output/programming operations. The step input clocks a ring counter that drives the multiplexer.

4.26 The 1 output of fourth decade counter in the 3814 is buffered and used as a divide-by-twenty thousand (÷20,000) output. This output is used to indicate a signal that is less than 10% of full scale. If the transfer pulse is enabled (falling edge) before the ÷20,000 output goes high; the output will signal the autorange circuitry that a range change must be made.

4.27 The Q0 and Q1 F/F outputs of the sixth (1/2 decade) counter are designated as QE0 and QE1 outputs. These outputs step the DMM through the various periods of the integration process. These signal codes are:

QE0	QE1	
1	1	50 ms – Signal integration – decade counts from 300,000 to 399,999
0	0	50 ms – Reference integration – decade counts from 000,000 to 99,999
1	0	50 ms – Reference integration (overflow) – decade counts from 100,000 to 199,999
0	1	50 ms – Reset – decade counts from 200,000 to 299,999

4.28 The QE1 output is latched and used as the QE1L output. If a DMM uses a full scale count of 199,999 using the 3814, the high state of QE1L is used to indicate an overrange condition. The QE1L output is inverted to drive the blanking inputs of U1 and U4, the BCD to seven segment decoders, causing the overload neon to be annunciated (O/L) and the segments of the display to go blank.

4.29 The edge sensitive Transfer input causes the BCD data in the counters to be stored in the latches on the falling edge. Synchronization with the clock is necessary to prevent loading and storing erroneous counter states as a "carry" is trickling through the counters. A Transfer command is accepted once during an integration cycle. An internal F/F is reset by the counter transition from 399,999 to 000,000. It is set when a Transfer occurs and remains set until the next integration sequence. No Transfers will be accepted when this F/F is set.

4.30 The clock pulse is constantly adding counts to the counter. As previously mentioned the states of QE0 and QE1 control the state of events that take place during an integration sequence.

4.31 QE0 – 1 and QE1 = 1. The counter advances from 300,000 to 399,999. This is the signal integration period. At this time the DMM input signal is attenuated, amplified, converted, and/or filtered and connected to the integrator input through a FET switch. The feed forward circuit of the integrator adds 100 digits of voltage to the integrator output to mask the switching transients that occur during the transitions from signal integrate to reference integrate.

4.32 QE0 = 0 and QE1 = 0. During this period the signal switch is turned off and a reference (plus or minus) is connected to the input of the integrator through a FET switch. The decade counter is set to 000,000 and the 3814 will ignore the next 10 counts. Because of the decade counter (units) before the 3814 clock input the first 100 counts are ignored. This period allows for masking the noise at the time when the signal integration is switched to the reference integration to prevent false zero detection at or near zero analog input signals. The count is started from 000,000 until the null detector crosses zero and signals the end of the reference integration period. Zero detect signals the Transfer input to store the BCD count of the decade counters into the latches. If the transfer occurs before the ÷1000 output goes true, the signal is less than 10% of full scale and a down range is commanded if the DMM is in autorange. If the count occurs at 100,000 counts the signal is full scale.

4.33 QE0 = 1 and QE1 = 0. This reference integration period is from 100,000 to 199,999 which is the overflow capability of the DMM.

4.34 QE0 = 0 and QE1 = 1. This is the reset period when the analog and reference inputs to the integrator are removed and FET switches short the integrator input to the output in a configuration called auto zero. The count of this period is from 200,000 to 299,999. If the QE1L output goes true before zero detect signals a transfer, an uprange is commanded if the DMM is in autorange and/or overload is detected and the display is blanked.

4.35 The step input from the ÷1000 output presents the multiplexed BCD outputs capable of driving a single decoder/driver, such as a SN7447. The decoded outputs 0_a to 0_e drive transistor circuitry that strobes the anodes of the display devices one at a time.

4.36 Automatic leading zero blanking is accomplished by circuitry using range data and the decoded outputs of the 3814. Example:

Range	Count	Display	Digit Fed Back
.1	0 in	.000000	–
1.	0 in	0.00000	–
10	.1 in	0.1000	D
100	.1 in	0.100	C
1000	.1 in	0.10	B
10000	.1 in	0.1	A

4.37 CLOCK.

4.38 The clock provides the primary timing for the instrument and drives the counter. The clock is crystal controlled, runs continuously, and operates at a frequency of 2 MegaHertz.

4.39 DISPLAY.

4.40 The information stored in the units latch is converted to 7-line logic and displayed on the units readout. The information stored in the LSI converted to 7-line logic and multiplexed to the remaining readouts. The coding is shown in table 4.1.

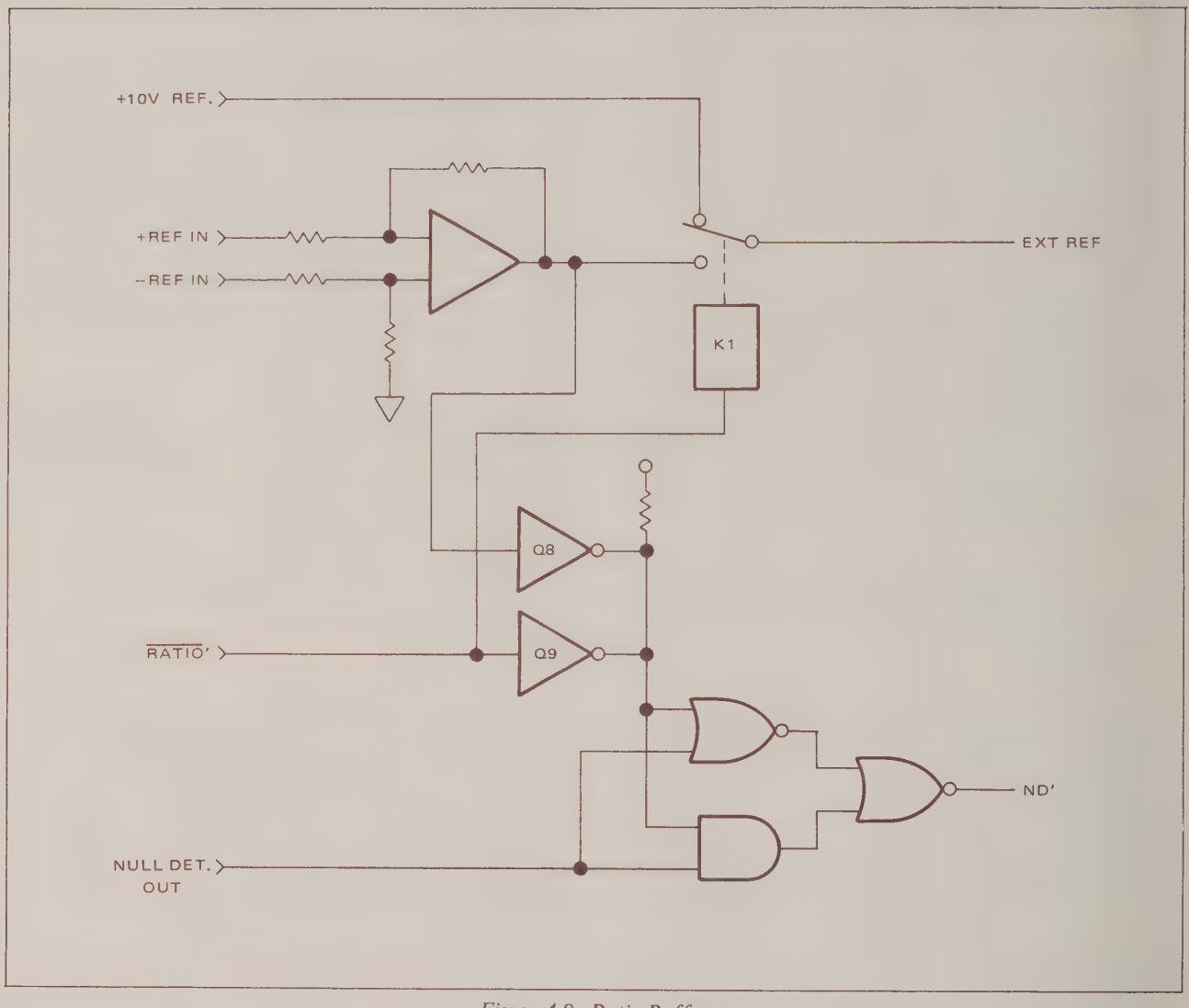


Figure 4.8 - Ratio Buffer

4.41 CONTROL LOGIC.

4.42 The control logic converts the timing signals originated by the LSI to control levels for generating the dual-slope integration sequence. The timing of this sequence is shown in figure 4.6.

4.43 REFERENCE AND BUFFER.

4.44 The reference and buffer circuit supplies two reference levels (+ and −10 volts) by which all measurements are compared. For internal reference the levels are a precise + and −10 volt level, generated by an extremely stable, zero temperature-coefficient, zener diode. For ratio measurement with instruments equipped with the ratio option, inputs of ±2 volts to ±11 volts can be used.

4.45 Ratio Buffer Option.

4.46 The Ratio Buffer Option consists of a bipolar operational amplifier shown in simplified form in figure 4.7. The gain of the amplifier is unity for X10 RATIO. The output of the buffer is monitored by transistor Q8 which acts as a polarity detector and controls the automatic 4-quadrant polarity gating circuitry. When the output of the buffer is positive, the data from the null detector passes through the circuitry unaffected (ND' = $\overline{ND}$); when the buffer output is negative, the Null Detector signal is inverted (ND' = ND). This affects both the Reference

Table 4.2 - Relay Logic

Function	Range	RELAY K1	K2	K3	K4	K5	K6	K7	K8	Iso Gain	Atten.
DC	100 mV									50	1
	1				■					5	1
	10	■	■		■					1	1/2
	100	■		■	■					5	1/100
	1000	■			■				■	5	1/1000
AC	1				■	■				5	1
	10				■	■				5	1
	100			■	■	■				5	1
	1000				■	■			■	5	1
KΩ	.1						■			50	1
	1				■		■			5	1
	10				■		■			5	1
	100	■	■	■	■		■			1	1
	1000	■	■		■		■		■	1	1
	10,000	■	■		■		■			1	1
Filter								■			

■ Indicates Relay is energized

Switching and Polarity. In Ratio mode, therefore, + polarity indicates that the input signal and reference signal are the same polarity (+/+, −/−) and − polarity indicates that the input signal and reference signal are opposite polarity (+/−, −/+).

4.47 RANGING.

4.48 The range circuitry drives the various attenuator and gain relays for the DMM measurement circuitry to achieve proper scaling of the input signal. This scaling may be in the form of either attenuation or gain according to the range and function selected and is obtained by the settings of various relays in the instrument as shown in table 4.2.

4.49 Range selection is either manual with the desired range selected by the front panel range switch, or autorange with the optimum range for the signal being measured selected by the range logic automatically. The autorange circuitry upranges when the input signal reaches 100% over full-scale and downranges when the input signal drops to 10% of full-scale. The data generated by the range circuitry is in the form of Binary Coded Decimal (BCD) 1-2-4-8 coding and decoded into 10-line for relay and logic control as shown in figure 4.9.

4.50 Manual Range.

4.51 The circuitry used in manual range consists of the range switch and encoding logic. Each switch position generates a specific BCD code. The code is applied to the input of up/down counter U24. In manual range, the $\overline{\text{LOAD}}$ input of the counter is held false and the BCD data is fed directly through the counter to the 10-line converters.

4.52 Autorange.

4.53 In autorange, the $\overline{\text{LOAD}}$ line is held true and the output of the up/down counter is independent of the BCD input lines. The counter is made to binarily count up or

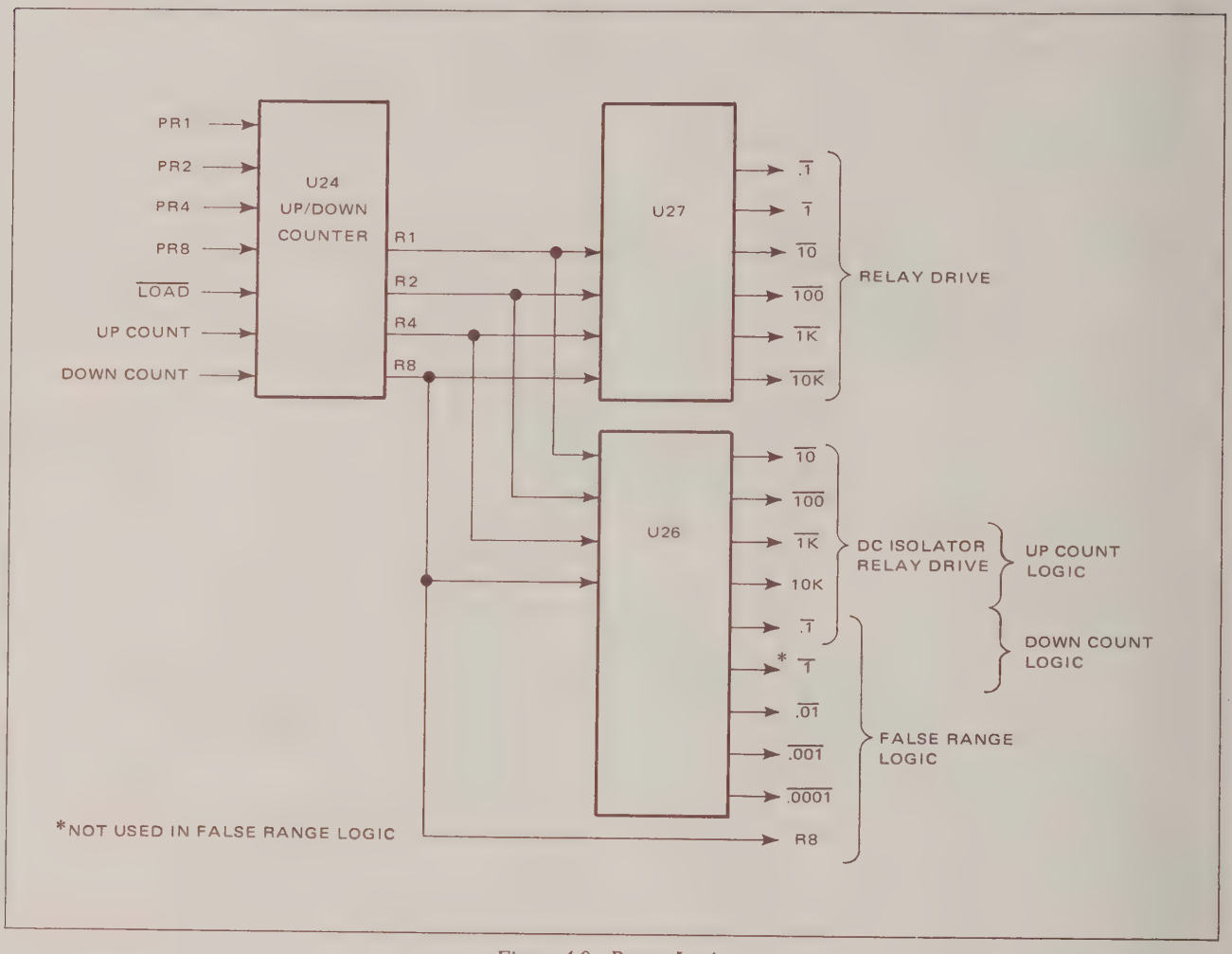


Figure 4.9 - Range Logic

down by administering a negative going pulse to the appropriate up count or down count input on U24.

4.54 The autorange circuitry is shown in figure 4.10. As indicated in the timing diagram, the down count pulse is generated at the end of the signal integrate period if $\leq 10\%$ of full-scale; the up count pulse is generated at the start of the reset period. Gates U30 and U31 prevent the counter from exceeding the upper or lower limits of the selected function. With an AC function selected, the $\overline{\text{RANGE CHANGE}}$ signal generated during an up count or down count pulse initiates a $\overline{\text{skip reading}}$ pulse, preventing the display of an erroneous reading.

4.55 False Range.

4.56 The false range circuitry detects illegal range codes while the instrument is in autorange. Whenever the FALSE RANGE signal goes true in Autorange, the DMM is forced into the 1000 range and then proceeds to the proper range.

Table 4.3 - Decimal Position

Range	Input				Display
	R1	R2	R4	R8	
100 mV	1	1	0	0	0 0 0 0 0 0
1	0	0	1	0	0 0 0 0 0 0
10	1	0	1	0	X 0 0 0 0 0
100	0	1	1	0	X X 0 0 0 0
1000	1	1	1	0	X X X 0 0 0
10,000	0	0	0	1	X X X X 0 0

X – May be Blank

4.57 Decimal Display.

4.58 The position of the decimal point in the readout is controlled by a BCD to 10-line converter. The input data to the converter is supplied by the up/down counter of the range control circuitry. The position of the decimal for each range selected is indicated in table 4.3.

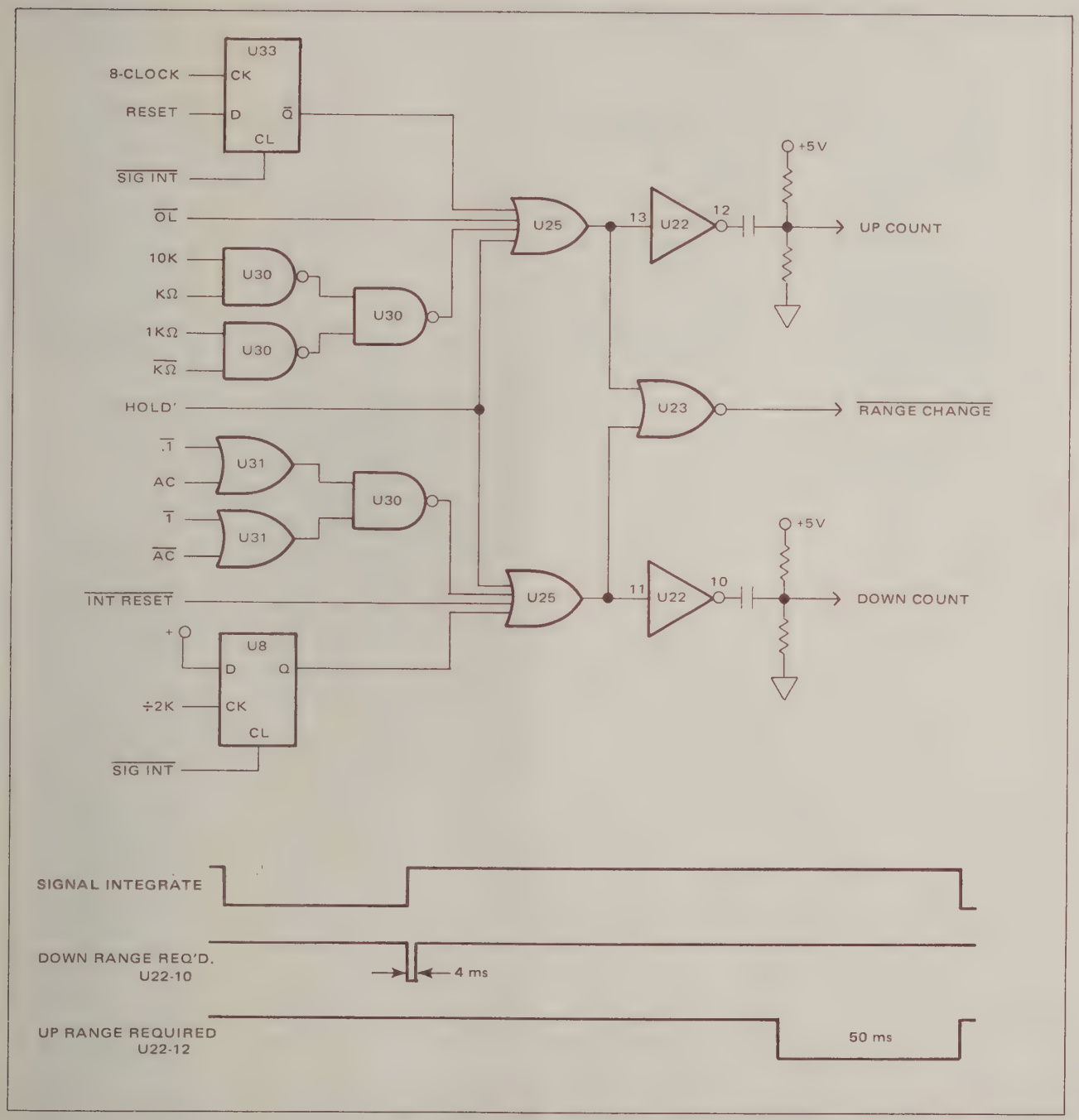


Figure 4.10 - Autorange Circuitry

4.59 Blanking.

4.60 Two types of blanking are used in the Model 5000 DMM. The overload blanking causes the entire display to go blank in an overload condition. The circuitry consists of the two BCD to seven line converters with the blanking inputs connected to the $\overline{OL}$ line. The zero blanking circuitry causes all zeros to blank that precede the first significant digit or a zero preceding the decimal point, whichever comes first. The majority of this circuitry is located in the 3814 counter/multiplexer and requires as input data, the location of the decimal point. This is supplied as a timed pulse by nand gates U9 and inverter U10B.

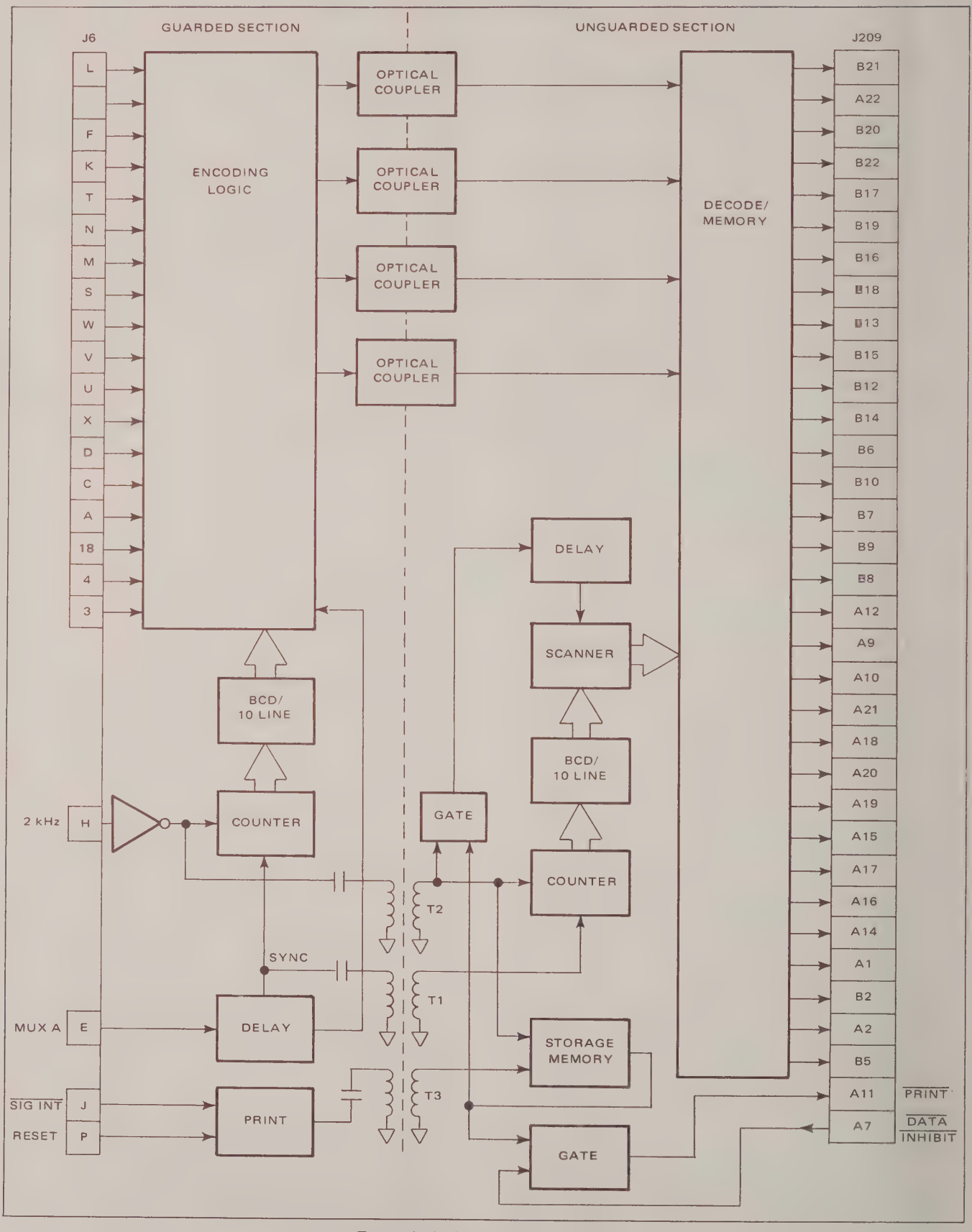


Figure 4.11 - Data Output Circuitry

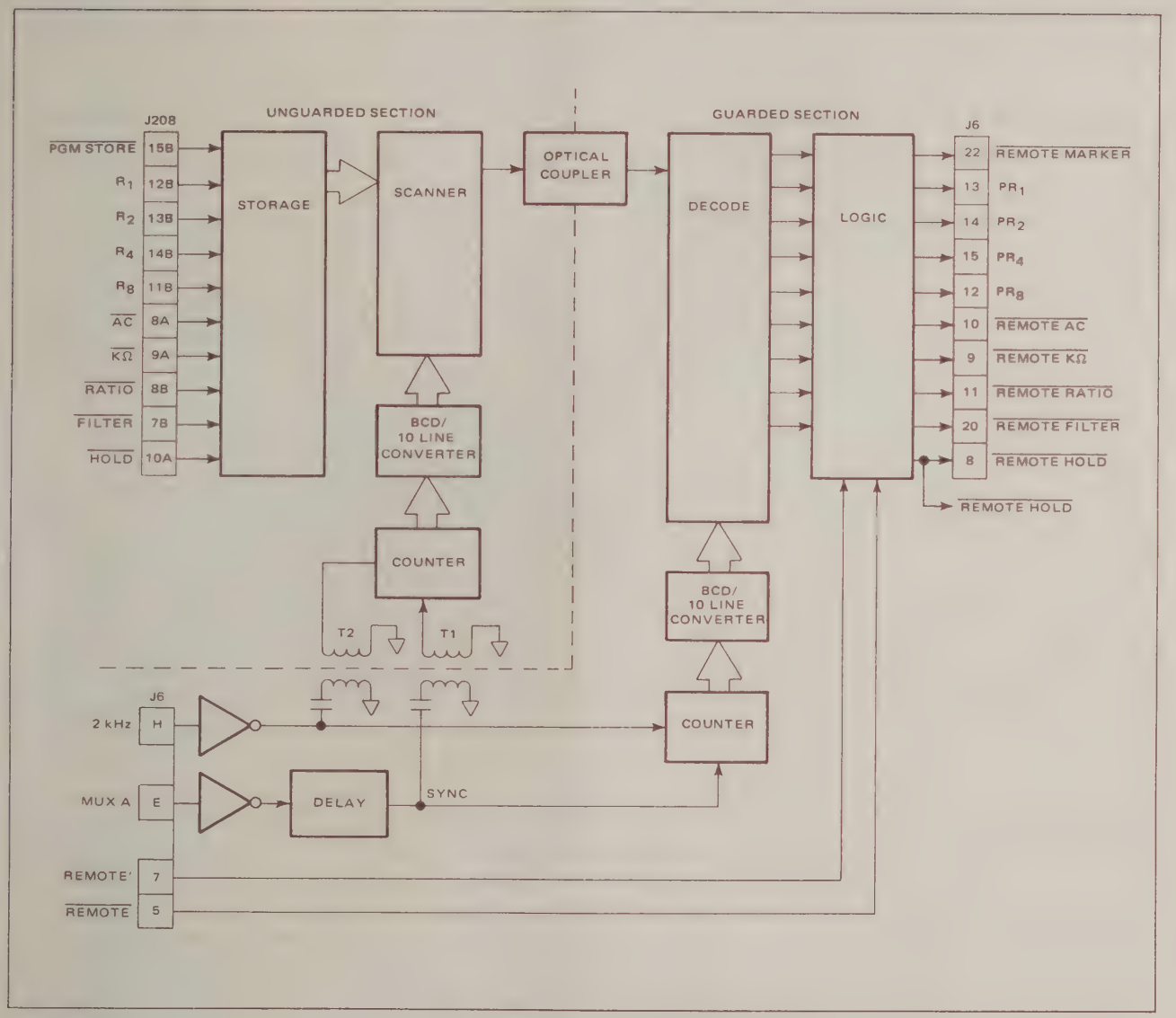


Figure 4.12 - Remote Programming

4.61 DATA OUTPUT.

4.62 The isolated BCD output uses the multiplexing technique to transfer the data generated in the guarded portion of the instrument to the output section in the unguarded portion. The multiplexing permits the numeric data, function, range, and polarity to be transmitted through four optical-couplers to eight storage latches in the output area as shown in the block diagram of figure 4.11. The print command, Direct Command and Delayed Command are isolated from the guarded section by means of isolation transformers.

4.63 REMOTE PROGRAMMING.

4.64 The programming circuitry also uses the multiplexing technique. As shown in the block diagram of figure 4.12, the programming inputs are stored by latches with the latches being strobed by the PROGRAM STORE line (if PROGRAM STORE is left high, the storage is bypassed). The data from storage is scanned at a 2 kHz rate and the data in serial form is fed to the guarded section of the instrument by a single optical coupler. The data is reconverted to parallel data and decoded for use by the instrument. The programming data is accepted by the instrument circuitry when the Remote function is selected.

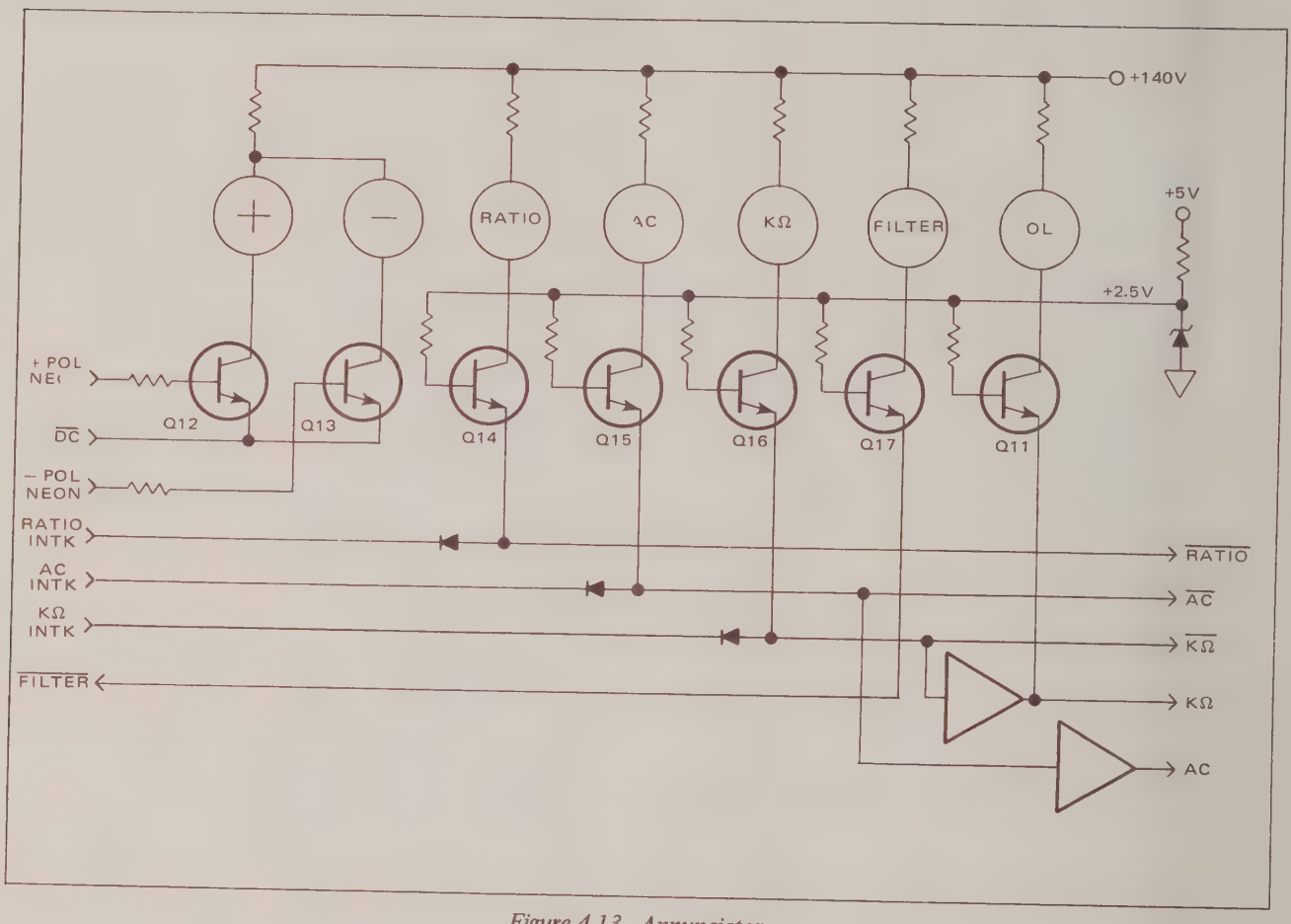


Figure 4.13 - Annunciator

4.65 ANNUNCIATOR.

4.66 The annunciator indicates the polarity, the function other than DC, the presence or absence of the filter and an input signal overload condition. The logic used to control the annunciator is shown in figure 4.13.

4.67 POWER SUPPLY.

4.68 The power supply is shown complete in figure 6.3 of the drawing section. The +5 volt supply is an integrated unit, the +27 supply is unregulated and +22 volt supply is an emitter follower buffered zener supply. The −12 and −24 volt supplies are straight Zener regulated supplies. The + and −18 volt supplies operate in an identical manner; the +18 volt supply will be used as the example: CR44 provides a +12 volt reference at emitter of Q53 with the base of Q53 monitoring the output of the supply through a voltage divider. The collector of Q53 controls the output level through emitter follower Q51. Transistor Q52 overrides the base circuit of Q51 in the case of overload and prevents the transistor from overdissipating.

SECTION 5 CALIBRATION

5.1 GENERAL.

CAUTION

Line Voltages as high as 240V, 60 Hz are exposed on the primary side of the power transformer and DC voltages as high as 160 volts are exposed on the secondary side. Exercise caution when working near the power supply and annunciator to avoid shock.

5.2 This section contains data for performing required periodic adjustments and, if needed, for locating and repairing instrument malfunctions. The section consists of the calibration procedure beginning at paragraph 5.3 and the troubleshooting guide beginning at paragraph 5.8.

5.3 Calibration Procedure.

5.4 The calibration procedure is provided to keep the instrument operating within its published specifications for indefinite periods of time. The location of the calibration points is given in figure 5.1. The calibration points are accessible by removing the top cover. No extender is required for calibration.

5.5 The procedure is provided with two circuit drawings (figures 5.2 and 5.3) that indicate the circuitry being adjusted. The adjustment sequence is arranged to minimize interaction of the controls and must be followed as provided.

5.6 Required Calibration Equipment.

5.7 The equipment needed for the calibration of the DMM is given in table 5.1. The type indicated is for reference only; comparable equipment having the same accuracy and resolution can be substituted.

5.8 Troubleshooting.

5.9 This procedure is provided to aid in locating the cause of an instrument malfunction. The procedure consists of a systematic basic instrument operation check, a table of symptoms and probable causes, and a brief description of major areas of the instrument circuitry from a troubleshooting standpoint. To eliminate as much as possible redundant material, frequent reference is made to information located in other sections of the manual.

5.10 Troubleshooting Equipment.

5.11 The equipment listed in table 5.1 can be used for the procedure with the addition of an oscilloscope such as the Tektronix type 453. Access to the main circuitry is gained by removal of the top cover.

5.12 POWER SUPPLY CHECK.

5.13 Before proceeding with the analog and digital circuitry check that all the supply voltages are present. If a discrepancy is found, proceed to table 5.2.

Table 5.1 - Calibration Equipment

Name	Suggested Equipment	Note
DC Voltage Standard	Fluke 332A	For basic DMM calibration
Microvoltmeter*	Fluke 845A	
Insulated Adjustment Tool	JFD5284	
2-clipleads ≤ 12" long with minigator clips & covers		
5 Digit DVM	Dana Model 5000	Ratio option only
AC Lab Power Source	HP745/746	AC option only
Decade Resistance Box	ESI DEKABOX DB62	Ohms option only
2-1 kilohm, 1/4 watt, 5%, carbon resistors		

*Connect 10 Kohm decoupling resistor in series with + lead.

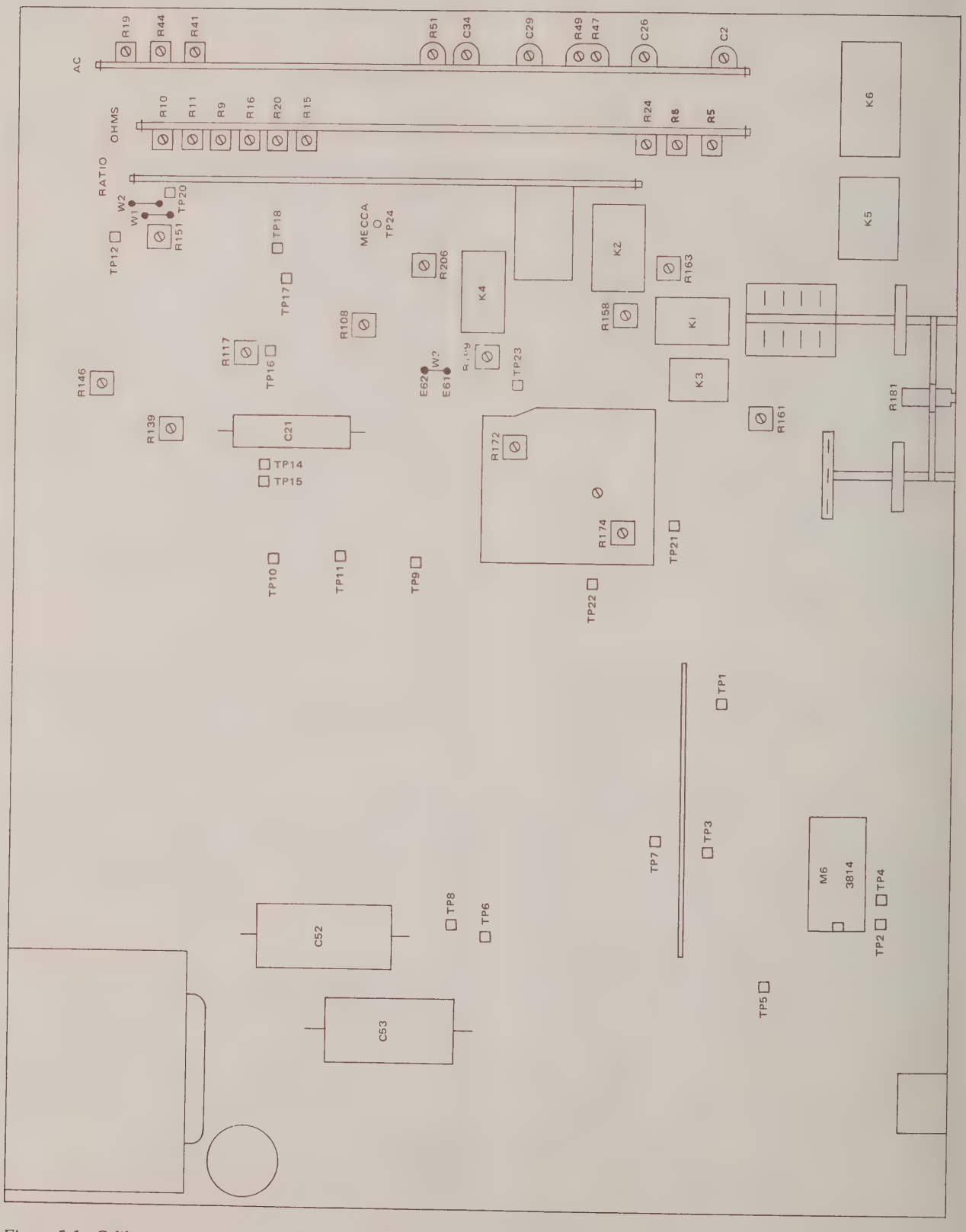
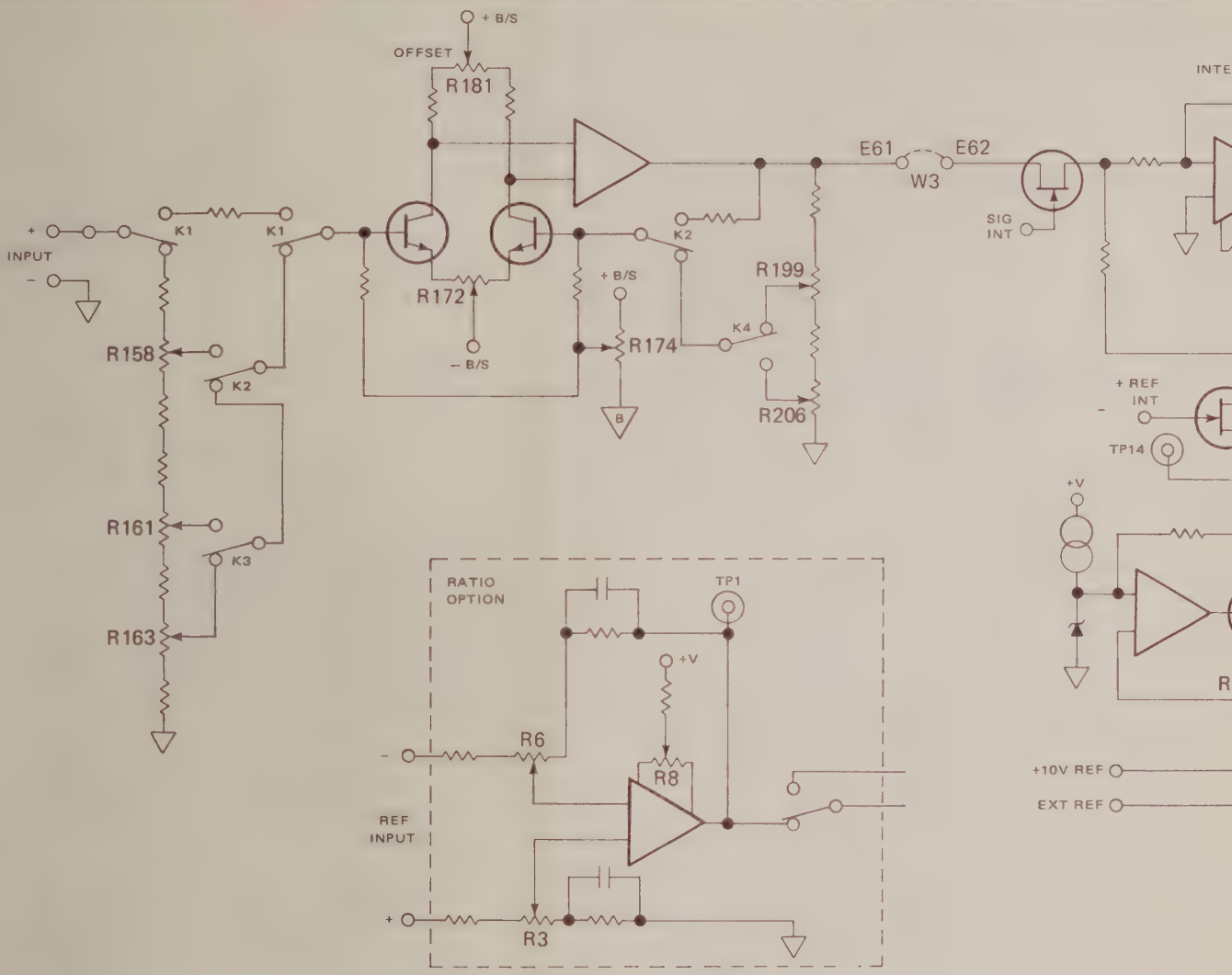


Figure 5.1 - Calibration Points



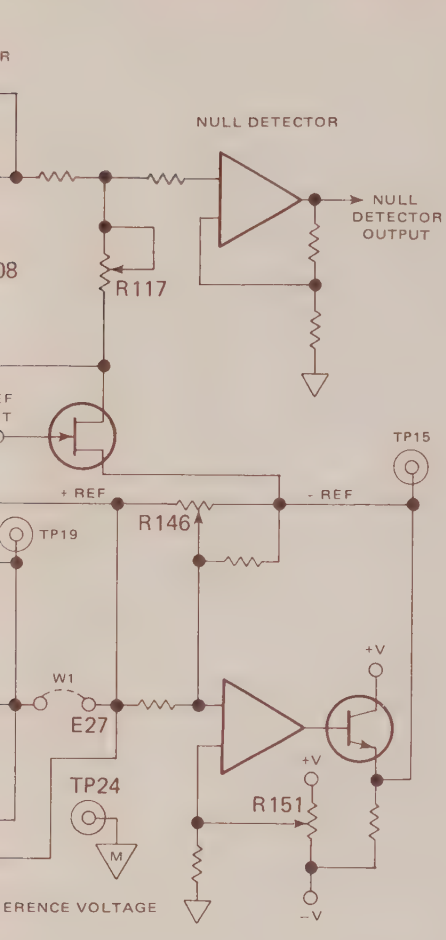
I. INTEGRATOR AND REFERENCE CALIBRATION

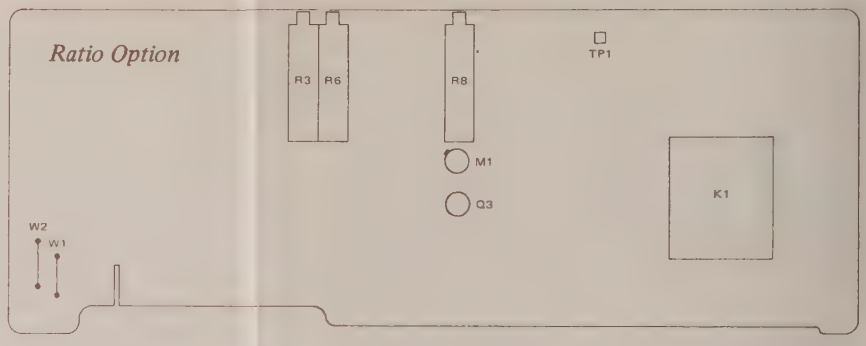
1. Remove jumper W3; short the ± INPUT terminals.
2. Apply +1 mV at E62; note readout.
3. Reverse polarity (−1 mV); note the readout. Alternately reverse the 1 mV input and adjust R108 until the numerical readout is the same in either polarity. (The final reading will be approximately mid-point of the initial readings.)
4. Adjust R117 for readout of 20 digits.
5. Remove jumper W1. Short TP14 to mecca (TP24). Connect microvoltmeter from TP15 to mecca.
6. Adjust R151 for zero ± 10 μV on microvoltmeter. Remove short (TP14 to TP24); reconnect jumper W1.
7. Apply −5V between E62 and mecca. Adjust R139 for display of −100000.
8. Apply +5V between E62 and mecca. Adjust R146 for display of +100000. Replace jumper W3.

NOTE

For instruments having the ratio option, continue with the following steps.

9. Short ± INPUT terminals; short ± REF IN terminals. Connect microvoltmeter between TP1 (on ratio board) and mecca (TP24).





10. Adjust R8 on ratio board for ±10 μV on microvoltmeter.

11. Select DCV. Connect 5-digit DVM between TP14 (+ ref) and mecca (TP24). Note reading obtained.

12. Select ratio function. Remove short from across REF IN terminals; connect + REF IN to mecca (TP24). Apply +10.0000 volts at REF IN terminals. Adjust R6 for DVM reading at TP14 equal to that obtained in step 11.

13. Remove mecca lead from the + REF IN and connect to – REF IN. Adjust R3 for DVM reading at TP14 equal to that obtained in step 11. Remove all shorts at reference and input terminals.

II. ISOLATOR ZERO

1. Short input terminals. Select .1V DC range. Adjust front panel OFFSET pot R181 for ± zero readout.

2. Set range to 10; adjust R174 for ± zeros.

3. Recheck .1 range; adjust R181 (front panel OFFSET) for ± zero readout, if necessary.

4. Switch to 10 range; adjust R174 for zero.

5. Recheck .1V range; readjust R181, if necessary.

6. Remove input short; select auto range.

III. DC RANGE CALIBRATION

1. Select DC, .1V range. Apply +.1V from DCV source to input terminals. Adjust R206 for readout of +.100000.

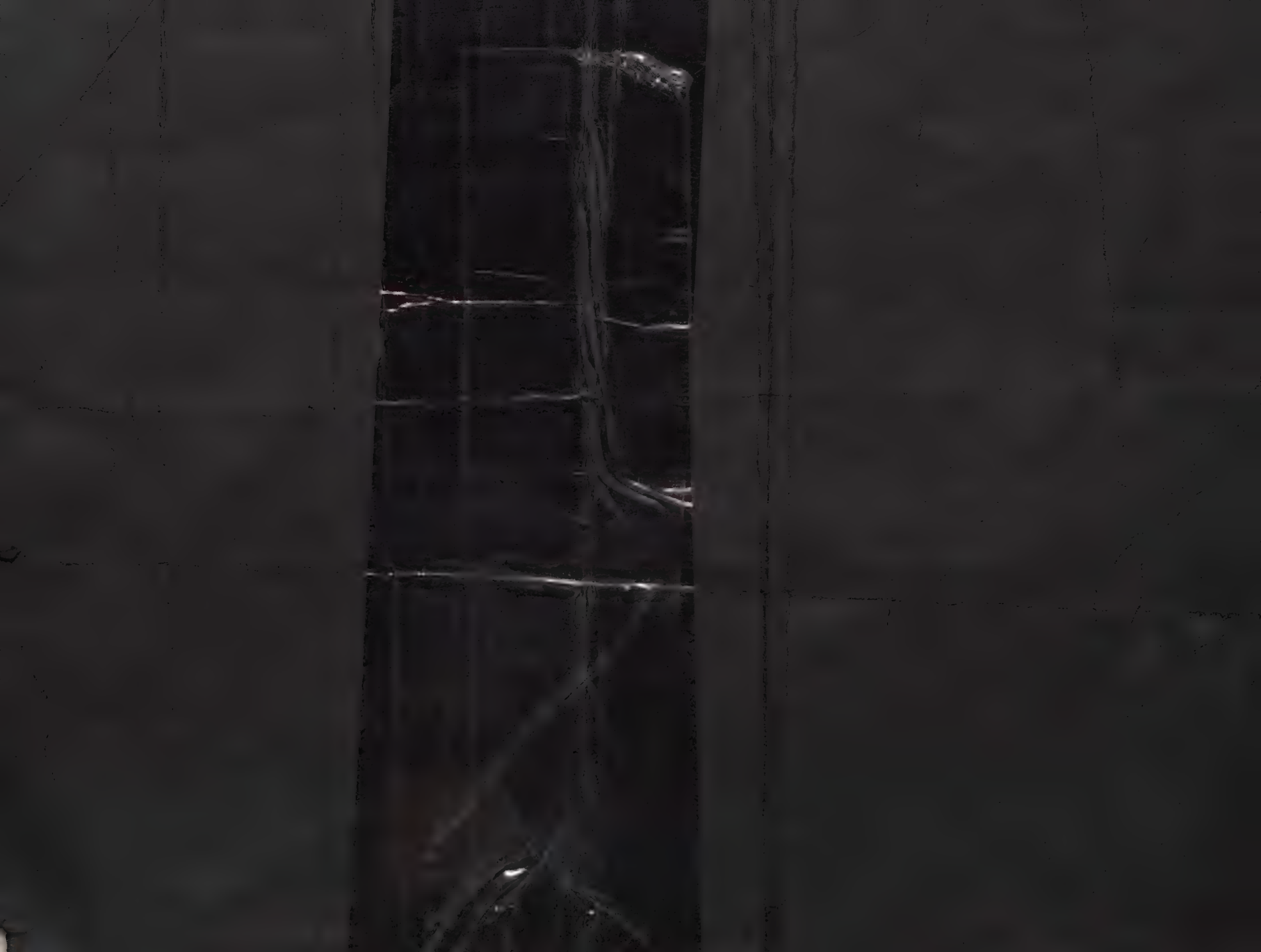
2. Select DC, 1V range. Apply +1 volt to input. Adjust R199 for readout of +1.00000 volts.

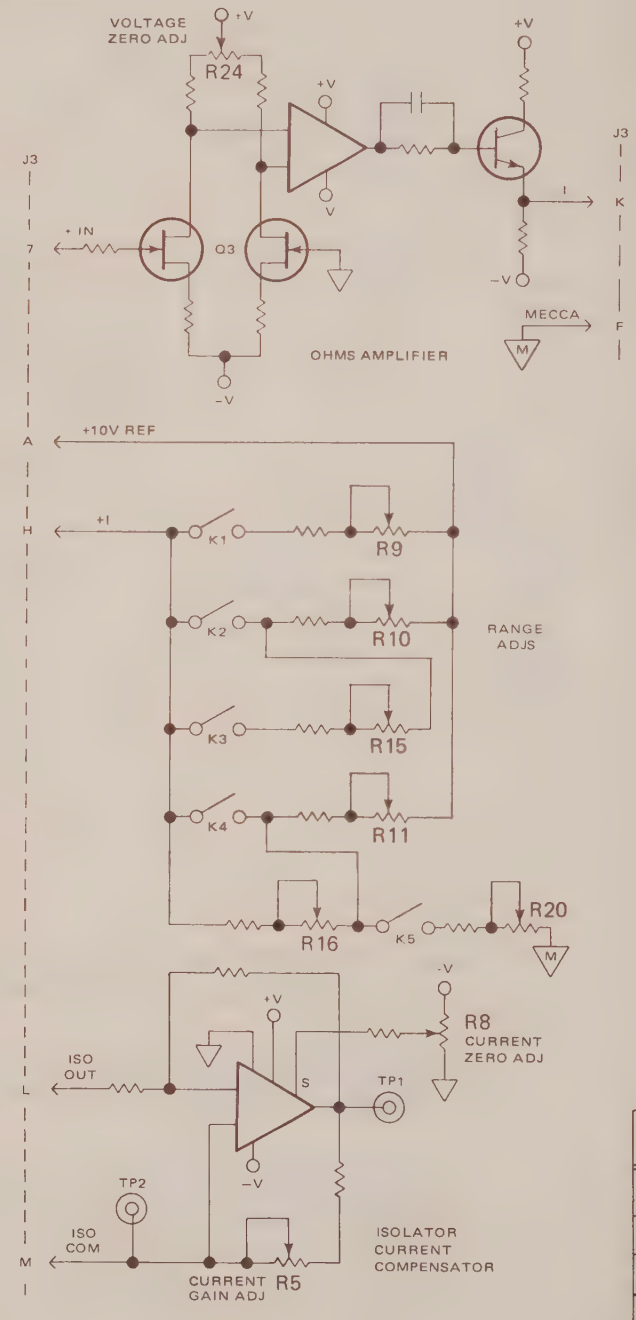
3. Select 10V range. Apply +10V to input. Adjust R158 for +10.0000 volt readout.

4. Select 100V range. Apply +100V to input. Adjust R161 for +100.000 volt readout.

5. Select 1000V range. Connect – INPUT lead of instrument to earth ground on DCV source (to minimize common mode voltage). Apply 100V to instrument. Increase input in 100-volt steps to 1000 volts. Adjust R163 for readout of +1000.00 volts. Decrease input voltage to zero.

Figure 5.2 - Basic Calibration





IV. OHMS CALIBRATION (Optional)

1. Short out the front panel + INPUT, – INPUT, and – CURRENT terminals. Connect + lead of microvoltmeter to + INPUT; – lead to mecca (TP24). Adjust R24 for $<\pm 10$ μvolts on microvoltmeter.

2. Select .1 VDC range. Adjust the front panel OFFSET for all zeros on readout.

3. Select 1 KΩ range. Connect microvoltmeter leads across TP1 (+) and TP2 (–). Adjust R8 for zero $<\pm 10$ microvolts.

4. Short + INPUT and + CURRENT terminals. Connect a standard 1 KΩ, 5% resistor between – INPUT and – CURRENT terminals. Connect the microvoltmeter across the resistor. Connect another 1 KΩ, 5% resistor across the ± CURRENT terminals. Adjust R5 for zero ± 10 μvolts on microvoltmeter.

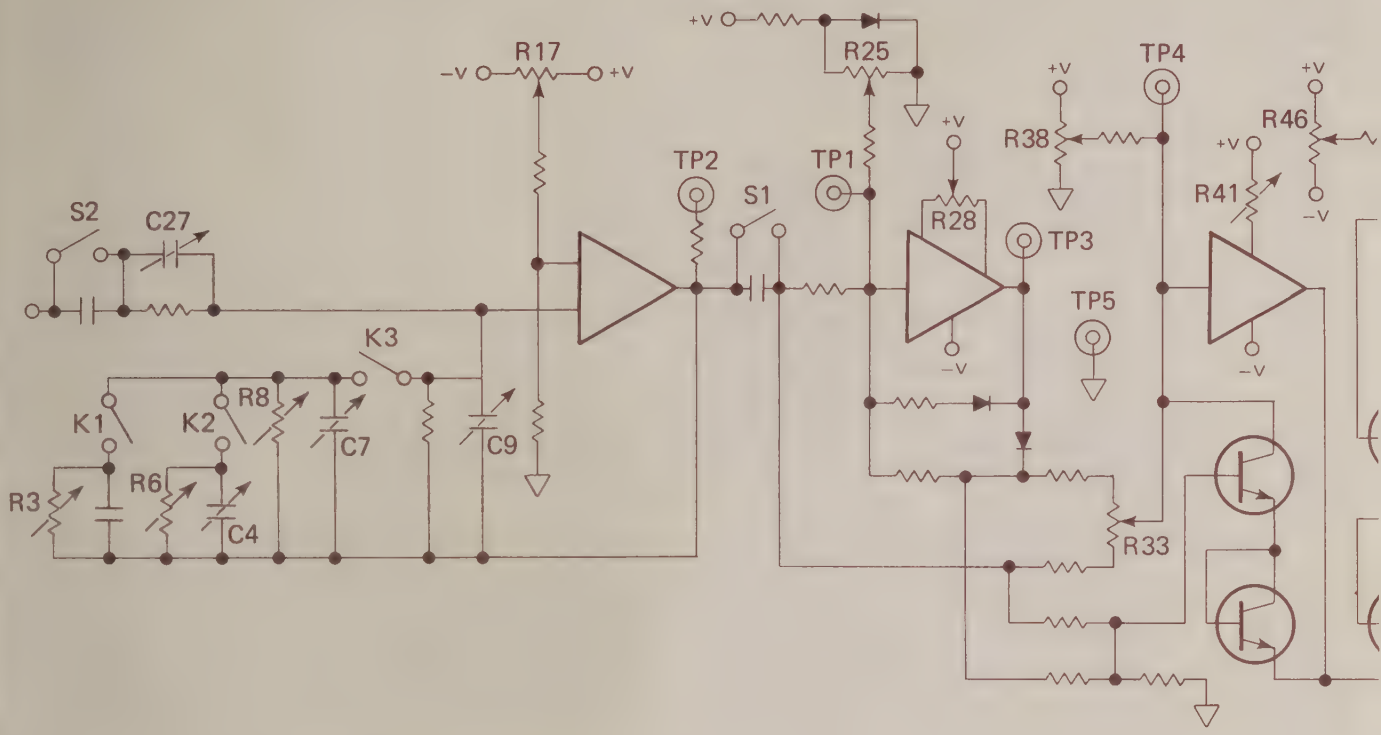
5. Remove all shorts and resistors from input terminals. Connect the Decade Resistance Box to front panel using the 4-wire ohms connection (figure 2.6).

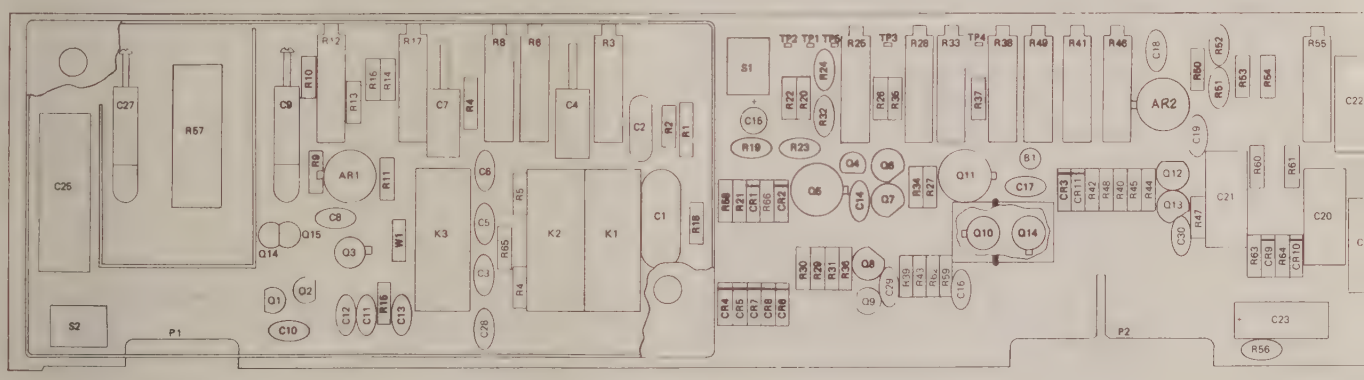
6. Set range to Auto. Set the decade box to the values listed in the following table. For each value, adjust the indicated control for the proper readout.

> **NOTE**
>
> It is necessary that the range adjustments be made in the order listed.

Set Decade Box to	Adjust	Readout
10 KΩ	R11	10.0000 KΩ
1 MΩ	R16	1000.00 KΩ
10 MΩ	R20	10000.0 KΩ
1 KΩ	R10	1.00000 KΩ
100 KΩ	R9	100.000 KΩ
.1 KΩ	R15	.100000 KΩ

Figure 5.3 - Ohms Calibration





VI. RMS AC CALIBRATION

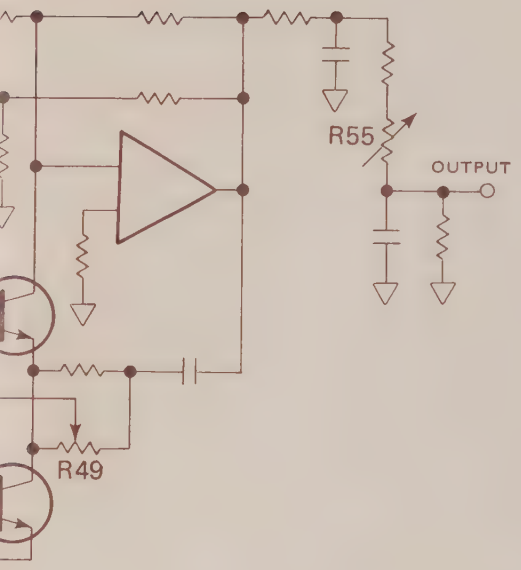
1. Set DVM power switch to off. Extract converter and remove environmental shield. Set S1 and S2 to DC (toward center of board), replace converter and set power switch to on. Select AC and 1 volt range on DVM front panel. Allow 10 minutes for temperature to stabilize.

NOTE

Use 10 KΩ resistor in series with + lead of microvoltmeter

2. Connect jumper across DVM input terminals. Connect the microvoltmeter to TP2 (+) and TP5 (–). Adjust R17 for a microvoltmeter reading of 0 ± 30 μV. Remove + microvoltmeter lead from TP2. Turn R38 fully clockwise.

3. Connect microvoltmeter + lead to TP4. Adjust R41 for a microvoltmeter reading of +20 ± 10 μV.



4. Connect + microvoltmeter lead to TP1. Adjust R28 for a microvoltmeter reading of 0 ± 30 μV. Remove microvoltmeter + lead from TP1.

5. Connect + microvoltmeter lead to TP3. Adjust R25 for 0 ± 30 mV. Remove + microvoltmeter lead from TP3.

6. Connect + microvoltmeter lead to TP4. Adjust R38 counterclockwise until the voltage at TP4 reads 0 ± 5 μV. Remove microvoltmeter leads and remove jumper across DVM input.

7. Apply −1.00000V DC and note DVM display.

8. Reverse polarity of input to +1.00000V DC and adjust R33 to obtain approximately the same DVM display as obtained in step 9. Repeat steps 9 and 10 until the two readings are within .01% of each other. Remove DC supply from DVM input.

9. Apply +0.10000 to DVM input and note DVM display.

10. Reverse polarity of input to −0.10000 and verify DVM display is within ±5 digits of the reading obtained in step 7. If not, use R25 to balance the readings. Select FILTER.

NOTE

R49 is an FSV adjustment and is reset only if major repairs have been performed on the converter. In this event, perform the following step.

10a. Apply a calibrated 1.00000V RMS pulse train with a crest factor of 7 and a period of 1 millisecond (1 kHz repetition rate). Adjust R49 for a readout of 1.00000. Remove the pulse generator from the DVM input and continue with the calibration procedure starting at step 11.

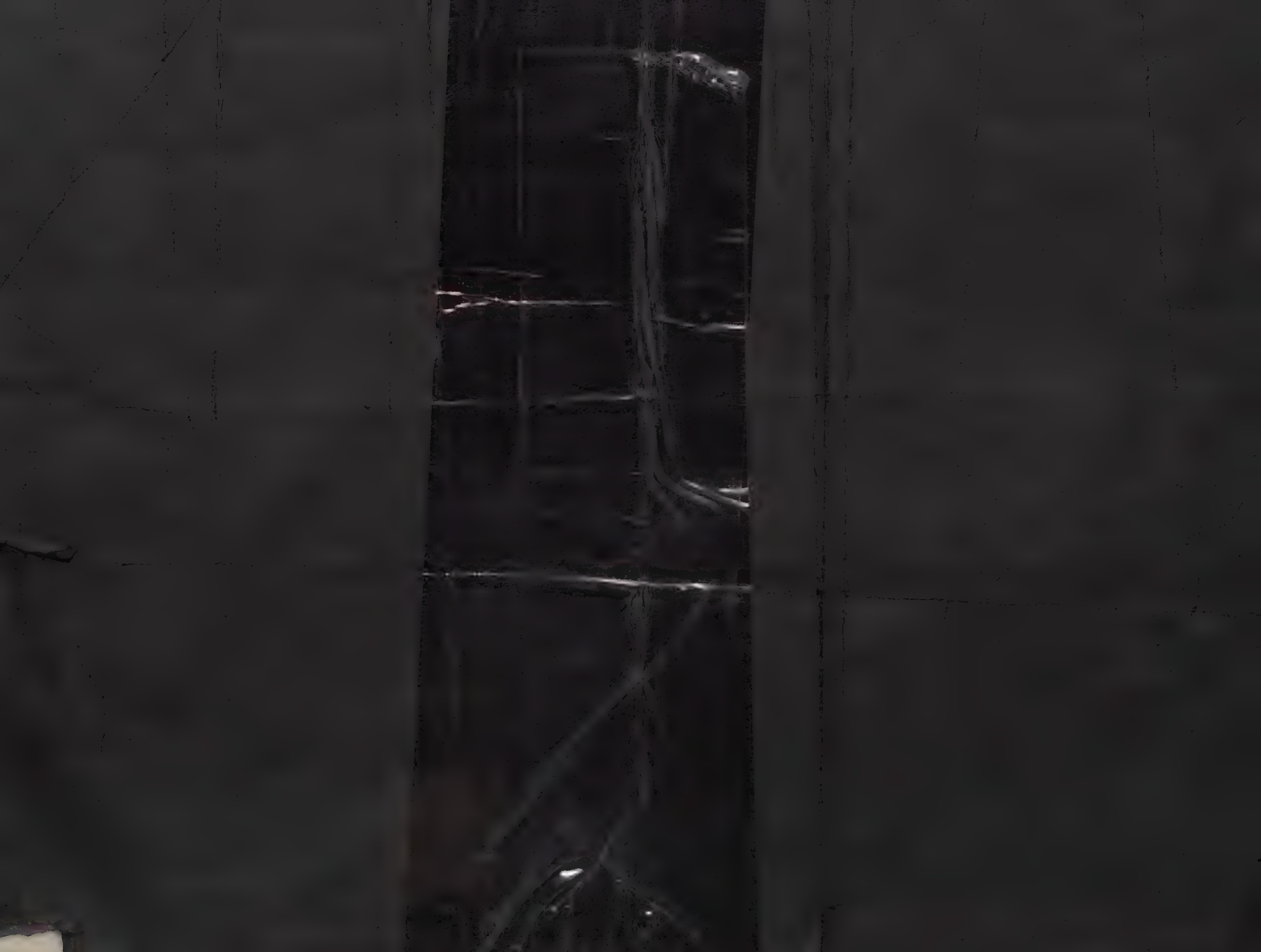
11. Set power switch on DVM to off, extract converter, set S1 and S2 to AC (away from center of board). Replace environmental shield on converter and replace converter in DVM. Reapply power and allow 10 minutes for temperature to stabilize.

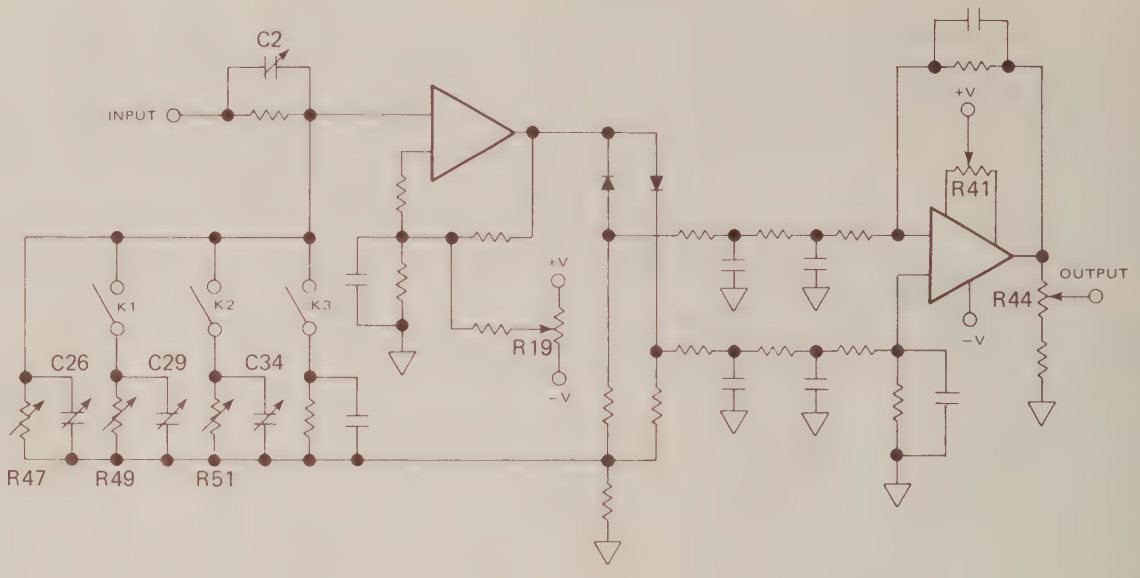
12. Connect the AC source to the DVM input terminals. Apply the inputs listed below and adjust the indicated control for the proper readout.

Range	INPUT		Adjust	Readout
	AC Voltage	Freq		
1V	1.0000	500 Hz	R55	1.00000
1V	.1000	500 Hz	R46	0.10000
Repeat steps for R55 and R46 until no adjustment is required.				
1000V	1000.0	500 Hz	R3	1000.00
1000V	500.00	40 kHz	C27*	500.000
1V	1.0000	50 kHz	C9*	1.00000
10V	10.000	500 Hz	R8	10.0000
10V	10.000	50 kHz	C7*	10.0000
100V	100.00	500 Hz	R6	100.000
100V	100.00	50 kHz	C4*	100.000

*Use an insulated screwdriver when adjusting the capacitors High voltage present on C27

Figure 5.4 - RMS AC Calibration





V. AC CALIBRATION

1. Select AC, 1000V range. Short ± INPUT terminals. Adjust R41 for readout of all zeros. Remove short at input.

2. Set range to 1V; apply 100 mV at 400 Hz from AC calibrator. Adjust R19 for minimum readout. Recheck step 1.

3. Apply inputs at 400 Hz on each range as listed below. Make the indicated adjustment for the proper readout.

Range	Input (RMS)	Adjust	Readout
1000	1000V	R44	1000.00
1	1V	R47	1.00000
10	10V	R49	10.0000
100	100V	R51	100.000

4. Change calibrator to 100 kHz. Apply inputs on each range as listed below. Adjust for proper readout.

Range	Input (RMS)	Adjust	Readout
1000	100V	C2	100.00
1	1V	C26	1.00000
10	10V	C29	10.0000
100	100V	C34	100.000

Figure 5.5 - Averaging AC Calibration

Table 5.2 - Power Supply Check

Low or Zero output of Supply:

1. Set power switch to OFF.
2. Remove all plug in boards to eliminate possible sources of shorts.
3. Apply power and recheck supply output.
   a. If normal, check plug in boards
   b. If low, check components on main board for excessive heat dissipation.

No output of any Supply:

1. Disconnect power cable from line voltage and back of instrument.
2. With power switch on, check for continuity (Low DC resistance) between HI (pin 2) and LO (pin 1) of J203 (typically, 110 volt range is 12Ω, 220 volt range is 35Ω). An open indicates a failure of F1, S5, S6, or S7.

5.14 Operational Check.

5.15 The check consists of narrowing down the problem to a specific area or circuit. This is done by checking out the basic instrument functions in a prescribed sequence and referring to the troubleshooting guide when the instrument fails to perform as indicated.

5.16 PRELIMINARY INSTRUMENT SETUP.

a. Select DC function, 1 Range, Filter OUT and PERIODIC mode.

b. Verify the line voltage selector on the DMM rear panel is positioned for the available line voltage and connect power cable.

Table 5.3 - Operational Check

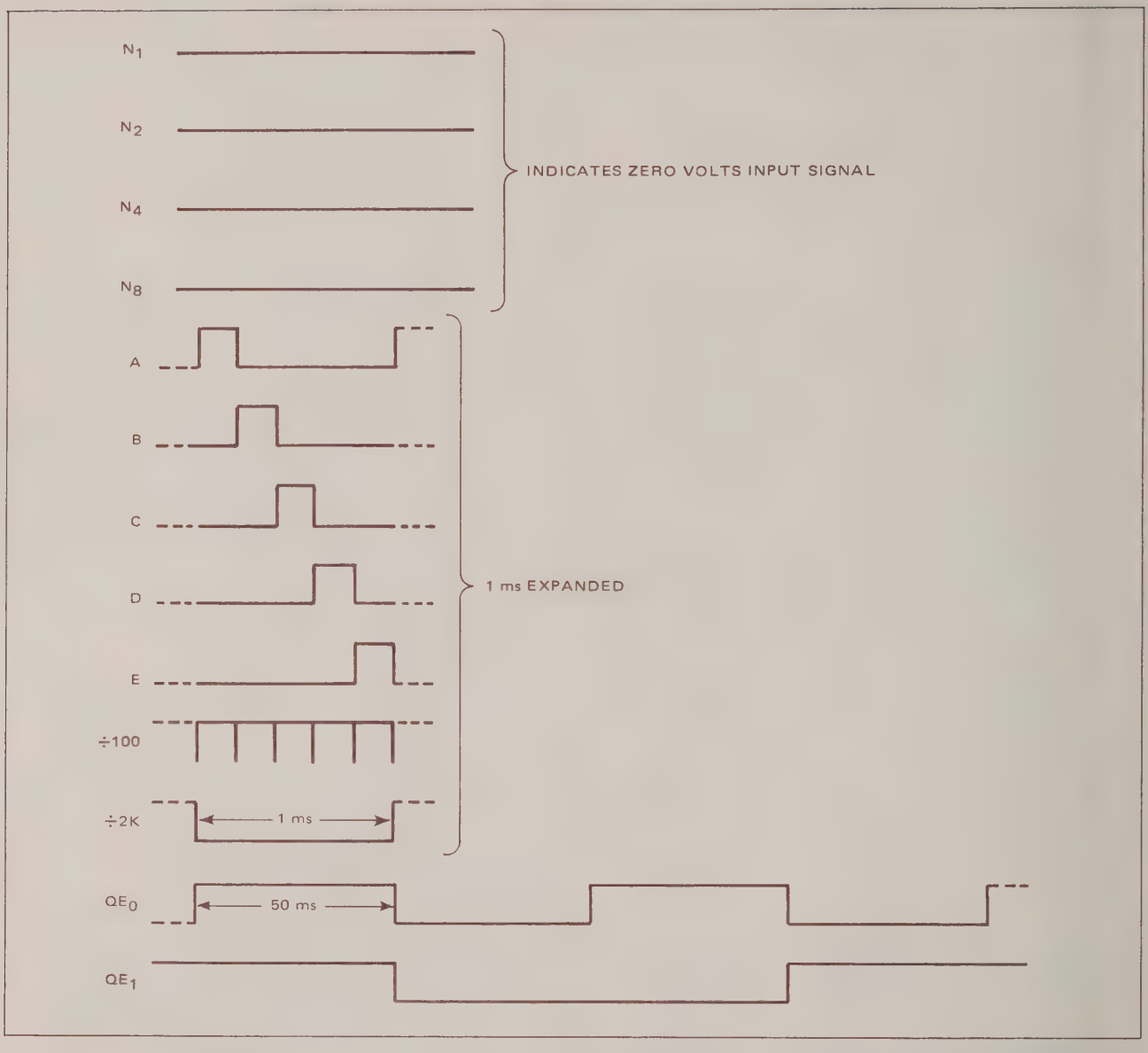
Step	Input	Annunciator	Display*
1.	a. Connect jumper across + and – input b. Set power switch on	+ or –	0.00000
2.	a. Remove jumper from input b. Apply +1 volt to input (DC source)	+	1.00000
3.	Reverse Polarity of input source	–	1.00000
4.	Select 100 mV range on DMM	– OL	•
5.	Reduce input to –0.1 volt (DC source)	–	100.000
6.	Select 10 volt range on DMM	–	00.1000
7.	Select 100 volt range on DMM	–	000.100
8.	Select 1000 volt range on DMM	–	0000.10
9.	Increase input voltage to –200 volts	–	0200.00
10.	Reduce DC Source and remove source from input		
	*May require adjustment of front panel offset		

c. Perform the checks indicated in table 5.3; if the instrument fails to provide the indicated output, refer to table 5.4 for assistance.

Table 5.4 - Troubleshooting Guide

Symptom	Diagnosis	Probable Cause	Paragraph
Display Blank	Instrument Overload	Range Logic	5.34
		A/D Converter	5.28
Decimal point wrong position	Range Logic		5.34
Display does not change with a change in input signal	Instrument locked up	Clock	5.20
		Units Decade	5.21
		4-1/2 Digit Counter	5.23
		Control Logic	5.25
		Integrator Logic	5.26
	Transfer pulses not generated	Transfer F/F	5.27
	Null Detector signal not generated	A/D Converter	5.28
Display numbers incorrectly formed	BCD to 7-Line Converters		5.24
Manual range selection incorrect	Range Logic	Manual Range Encoding	5.35
Readout does not Zero properly	Offset Error	Compensation Circuit	5.31
	Transfer Error	Analog Error	5.38
		Transfer Inhibit	5.27

Table 5.5 - 4-1/2 Digit Counter/Multiplexer Outputs



5.17 CIRCUIT DESCRIPTIONS.

5.18 The remaining paragraphs describe the operation of the instrument circuitry from the standpoint of specific operating characteristics. These are to be used in trouble-shooting to verify proper operation. The majority of the circuitry operates in a linear flow; that is, a signal is generated at one point and processed, encoded, decoded, or converted through various other circuits. If the output of one of the circuits is incorrect, the circuit is bad.

5.19 Measurement Logic. These circuits are covered in paragraphs 5.20 through 5.24, and include the counting and display logic. Symptoms of a failure in this area is the Display does not change with a change of input signal.

5.20 Clock. The clock (U10) runs continuously at 2 MHz and it drives only two circuits. If there is no signal, repair the clock.

5.21 Units Decade. This unit (U3) is the units decade, is driven by the 2 MHz clock and runs continuously. If it's not running, replace it.

5.22 Units Storage. This unit (U2) stores the information appearing at the four input lines (2, 6, 7, 3) upon receipt of a units transfer pulse; the stored data appears and remains at output lines (16, 10, 9, 15) until the next units transfer pulse.

5.23 4-1/2 Decade Counter. This unit (U6) has many outputs, the failure of any one of which would cause the

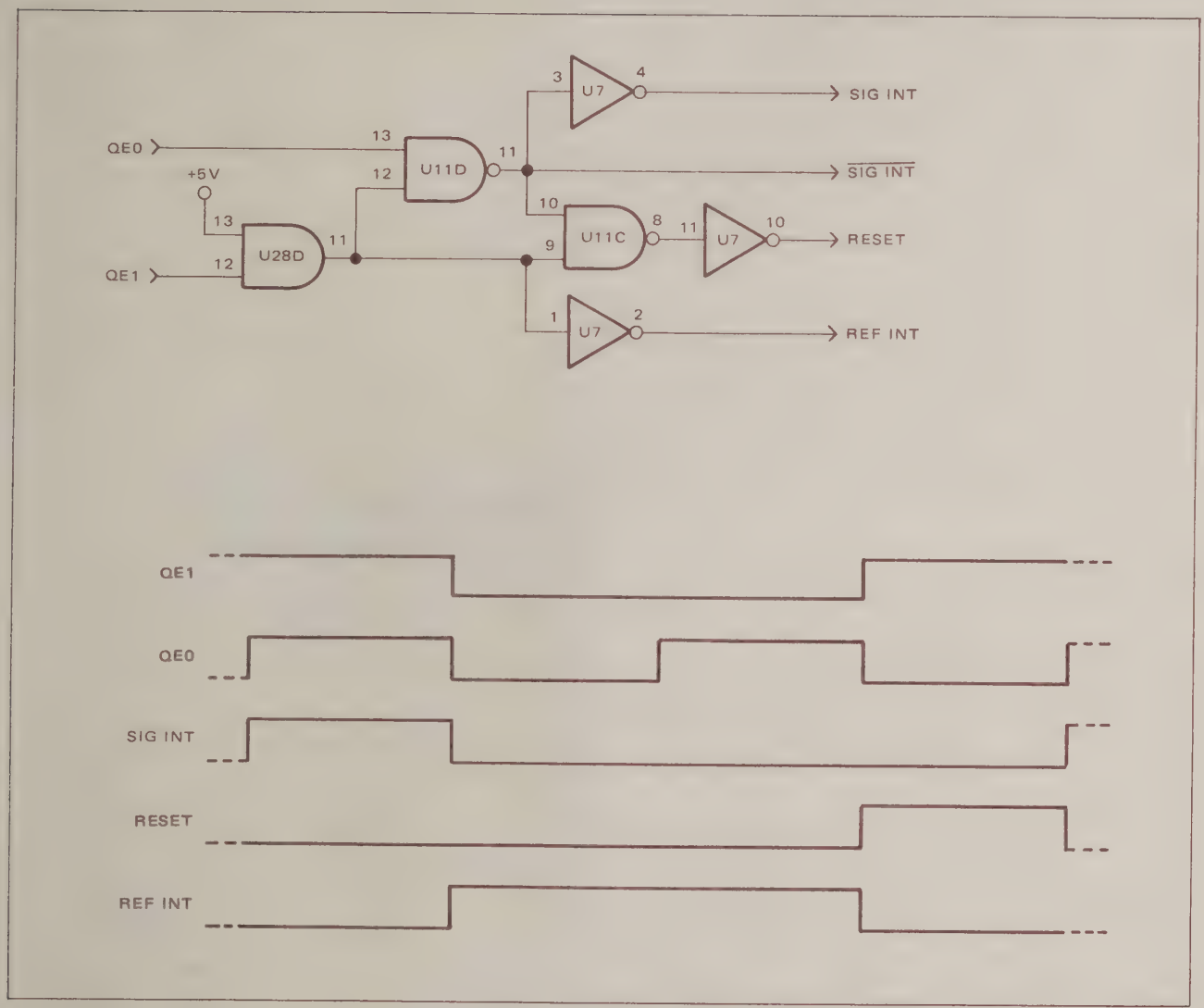


Figure 5.6 - Control Logic

instrument to malfunction. Representative waveforms are given in table 5.5. The device runs continuously and requires two signal inputs to operate: the 8 CLOCK and the $\overline{\text{Transfer}}$.

5.24 BCD to 7-Line Converters. These units (U1, U4) convert the data from the counters to 7-line for the display and provide the blanking function when the instrument is in an overload condition. These units may be checked by swapping if a malfunction is suspected.

5.25 Control Logic. This circuitry shown with timing in figure 5.6 decodes the Q_{E0} and Q_{E1} outputs of the 4-1/2 digit counter for use by other portions of the instrument. Failure of this circuitry would cause the instrument to lock up.

5.26 Integrator Logic. This circuitry, shown simplified in figure 5.7 controls the operation of the A/D converter. Timing of the circuitry is included with the figure for + and −10 volts input.

5.27 Units Transfer Inhibit. The units transfer inhibit prevents a transfer pulse from being applied to the units storage latch for a period of 50 μs (100 clock pulses) following the start of the Reference Integration period. This delay time corresponds to the analog delay incorporated in the Analog-to-Digital conversion circuitry. The circuit is shown in figure 5.8 with timing for zero volts input to the DMM. Referring to the figure, the REF INT signal sets $\overline{Q}$ (U34A-6), enabling Decade counter U35, clearing f/f U34B and inhibiting NAND gate U11 for a 50 μs (10 8-CLOCK counts); U34A is reset by counter U35. A normal

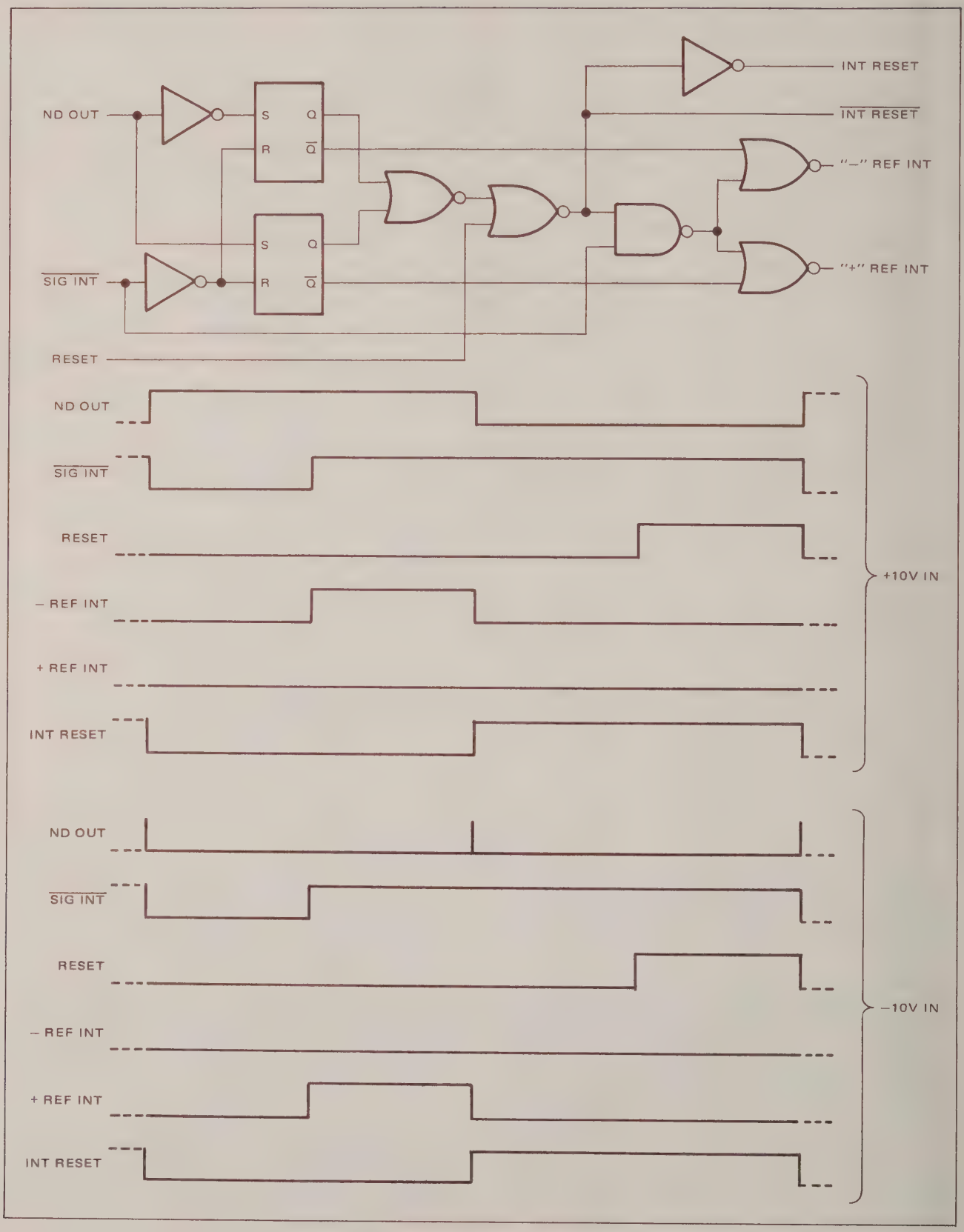


Figure 5.7 - Integrate Logic

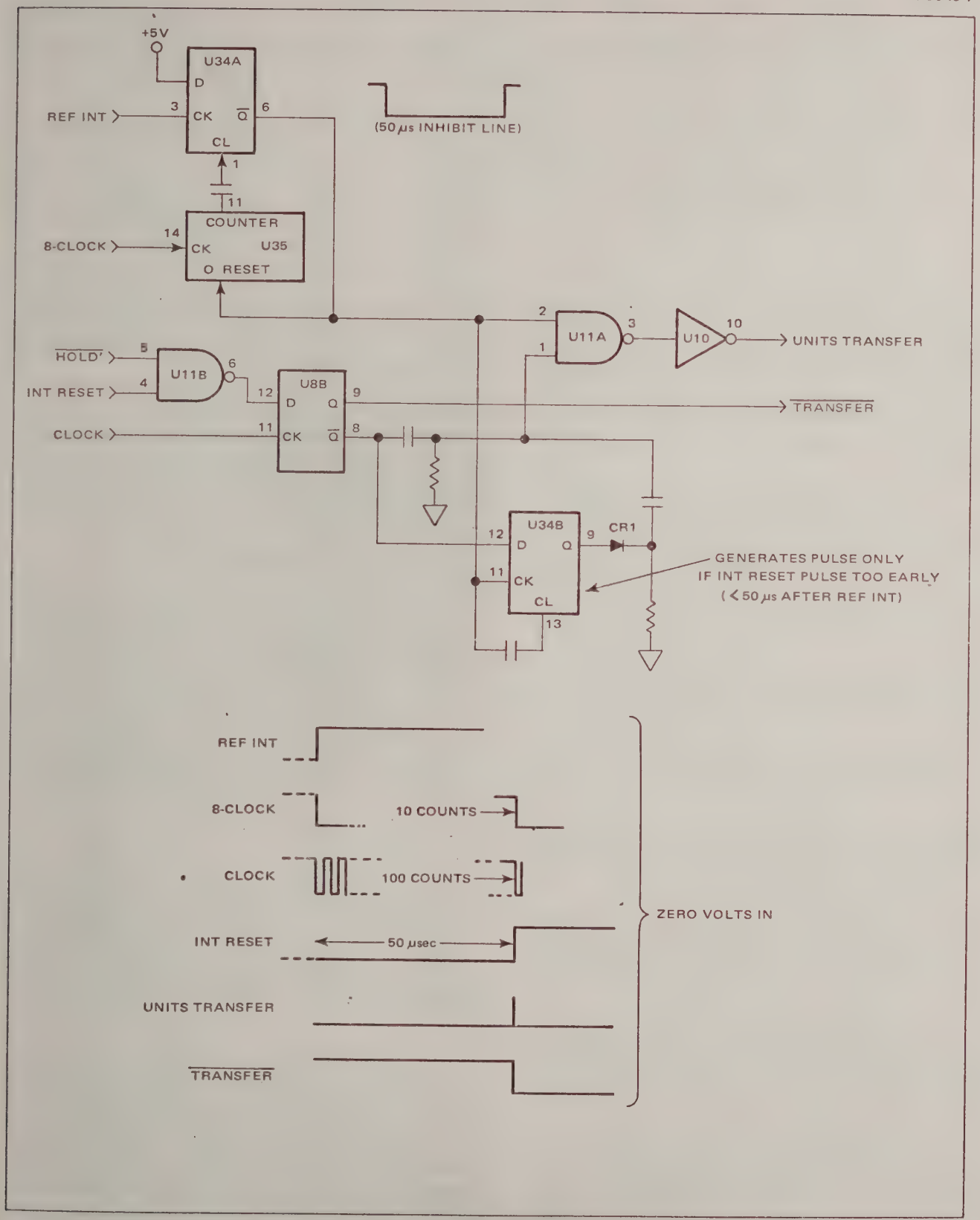


Figure 5.8 - Units Transfer Inhibit Circuitry

Table 5.6 - Units Transfer Malfunction

Symptom	Diagnosis	Probable Cause
Readout Locked Up	No $\overline{\text{Transfer}}$ or units Transfer Signals	U11B, U8B, ck. also $\overline{\text{HOLD}}$', INT RESET Lines
Units Locked Up	Units transfer pulse not generated or inhibited	U11A, U10, U34B, CR1
Units bounces between 0 and 9 at zero input	Inhibit line not working	U34A, U11A (also indicates analog offset on A/D converter out of adjustment)

INT RESET pulse for a zero volts signal input arrives 50 μs after REF INT, generating a $\overline{\text{TRANSFER}}$ signal and a units transfer pulse. An INT RESET arriving prematurely is inhibited from passing through U11, but sets the D line of U34B true. At the end of this 50 μs inhibit, U34B is clocked by the inhibit line going true and generates a units transfer pulse. Troubleshooting aids are provided in table 5.6.

5.28 Analog-to-Digital Converter. This circuit shown simplified in figure 4.6, consists of the switching circuitry, integrator, offset compensation, gain section, and null detector. The entire circuit is controlled by logic outside the converter. Errors in logic input signals therefore, are not caused by any malfunction in the A/D converter.

5.29 Switching Circuitry. The switching circuitry is controlled by Integrate logic (see paragraph 5.26).

5.30 Integrator. The integrator generates a linear ramp voltage (≈8.4 volt peak for a 10 volt input).

5.31 Offset Compensation. This circuit generates an offset of −10 millivolts for positive inputs and +10 millivolts for negative signal inputs.

5.32 Gain Section. This circuit provides a gain of 200 for inputs up to ±3.5 millivolts and a gain of 20 for larger inputs. The circuit amplifies the output of the integrator.

5.33 Null Detector. The null detector is a voltage level trigger and converts the output of the gain section to a digital signal. The output of the null detector is a square-wave pulse from zero to +3 volts.

5.34 Range Logic. The range logic controls the amplitude selecting areas of the DC Attenuator, Isolator, and AC converter. It also controls the positioning of the decimal point in the display. Basic operating theory of the range logic is covered in paragraphs 4.40 through 4.51 of the Theory section.

5.35 Manual Range. The circuitry for generating the range code is shown in figure 5.9. In the case of a malfunction of range selection, the proper coding for each range should be verified.

5.36 False Range. The false range circuitry generates a true signal whenever an illegal range code is generated in Autorange and causes the up/down counter to be forced into the 1K range. The circuitry for generating the false range signal and the codes for generating the signal are shown in figure 5.10.

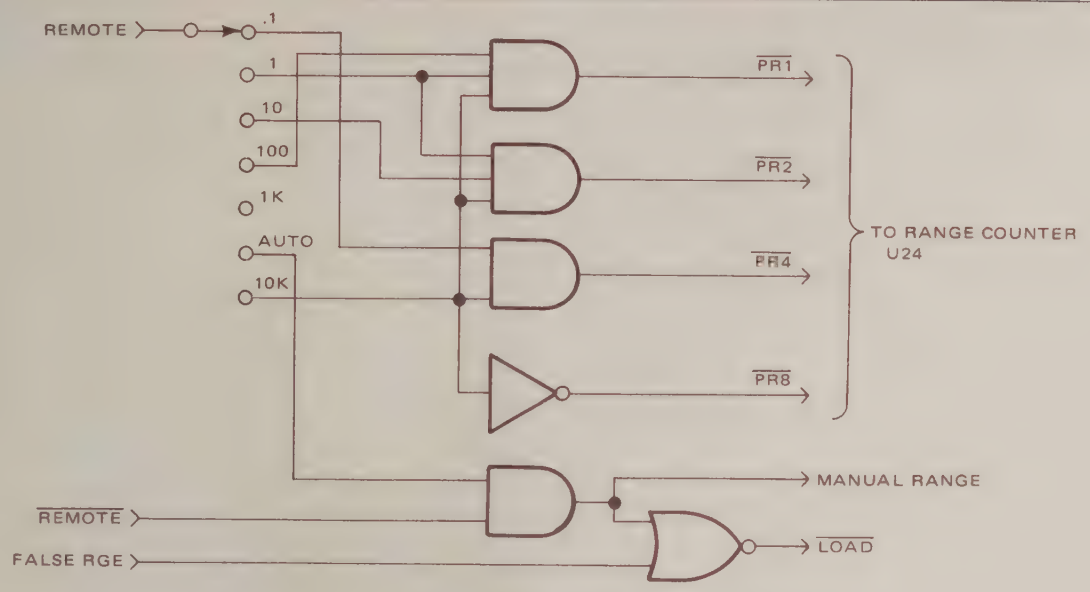
5.37 ANALOG AMPLIFIERS.

5.38 Analog amplifiers consist of either integrated amplifiers or integrated amplifiers with dual front-end stages. In the case of catastrophic failure or a single device it is usually a simple matter to determine the faulty component. In the case of apparent low gain on a hybrid circuit connect a microvoltmeter across the bases of the input stage and apply an input signal that changes from positive to negative. Verify that the microvoltmeter output tracks the input. If not, the input stage is probably at fault.

5.39 Board Revision.

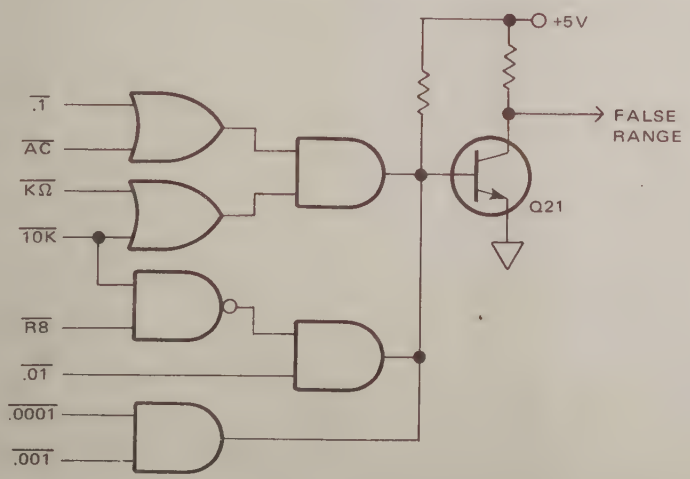
5.40 Every effort is made to keep the manual concurrent with the instrument despite changes to the design, which are an inevitable adjunct of the manufacturing process. The manual is updated and periodically reprinted throughout the year. In between printings, Addendums and Errata Sheets are added to the manual if required to implement the reprinted copy.

5.41 Any design change is accompanied by an updating of a board revision. Such change could be as simple as a revised hole size or as complex as major modifications of the circuitry. The revision of a board is indicated by the letter preceding the assembly number stamped on the board; the revision of the assembly drawing in Section 6 or on an Errata Sheet is indicated by the letter following the assembly number, located below the drawing. Comparing the revision letters can indicate how closely the drawing corresponds to the board.



RANGE	PR1	PR2	PR4	PR8	WEIGHT
0.1	T	T	F	F	3
1	F	F	T	F	4
10	T	F	T	F	5
100	F	T	T	F	6
1K	T	T	T	F	7
10K	F	F	F	T	8
AUTO	T	T	T	F	7

Figure 5.9 - Manual Range Logic



INPUT	FALSE RANGE				
	T	T	T	T	T
.1	F				
AC	F				
KΩ		F			
10K		F	T		
R8			T		
.01				F	
.0001					F
.001					F

Figure 5.10 - False Range Logic

SECTION 6 DRAWINGS

Figure	Title	Page
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6.4	Layout, Display	6-8
6.5	Schematic, Display	6-9
6.6	Layout, Ohms Converter	6-10
6.7	Schematic, Ohms Converter	6-11
6.8	Layout, AC Converter	6-12
6.9	Schematic, AC Converter	6-13
6.10	Layout, RMS Converter	6-14
6.11	Schematic, RMS Converter	6-15
6.12	Layout, Ratio Buffer	6-16
6-13	Schematic, Ratio Buffer	6-16
6.14	Layout, Data Output & Programming	6-17
6.15	Schematic, Data Output & Programming	6-17
6.16	Layout, Rear Panel	6-20

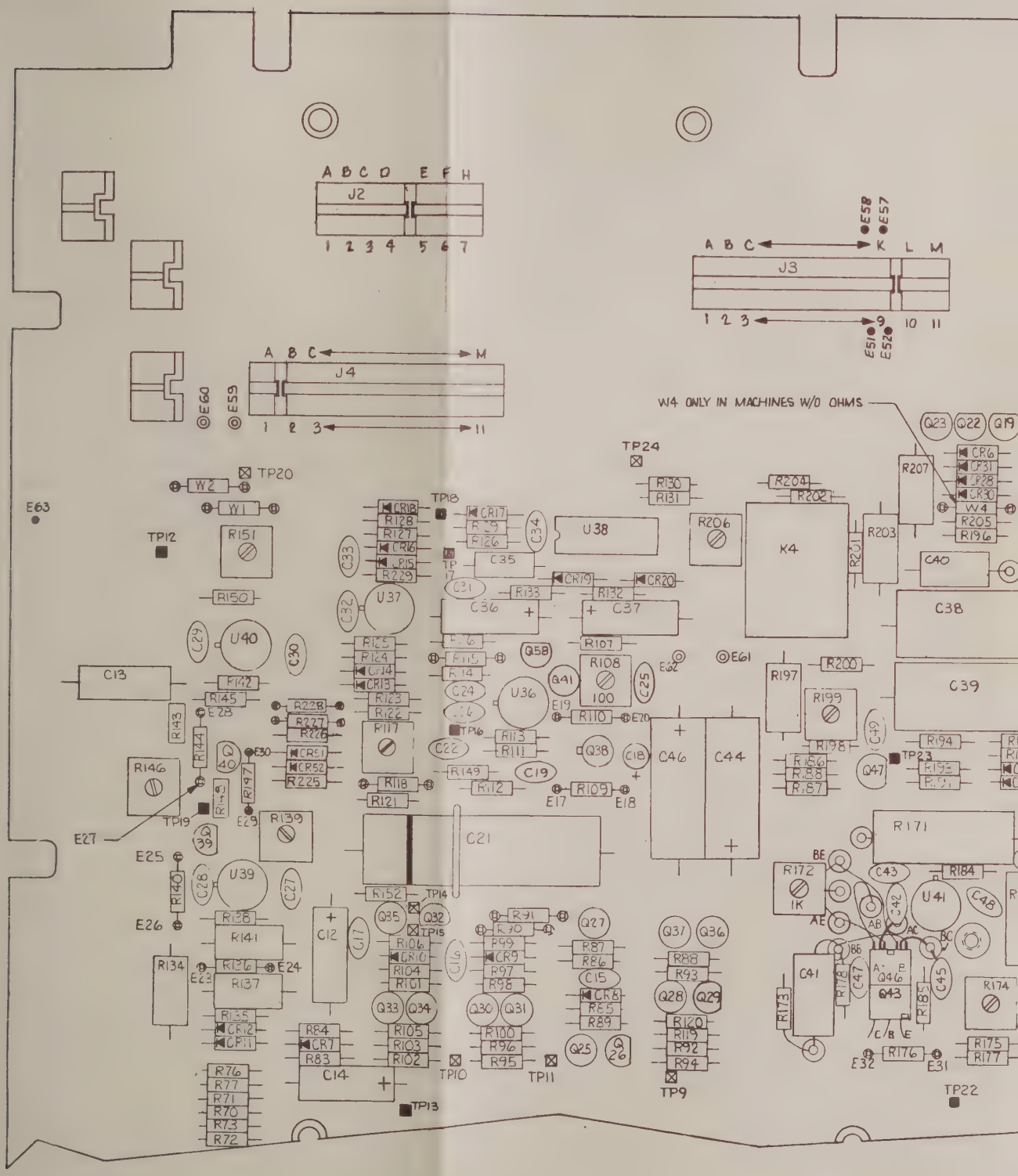
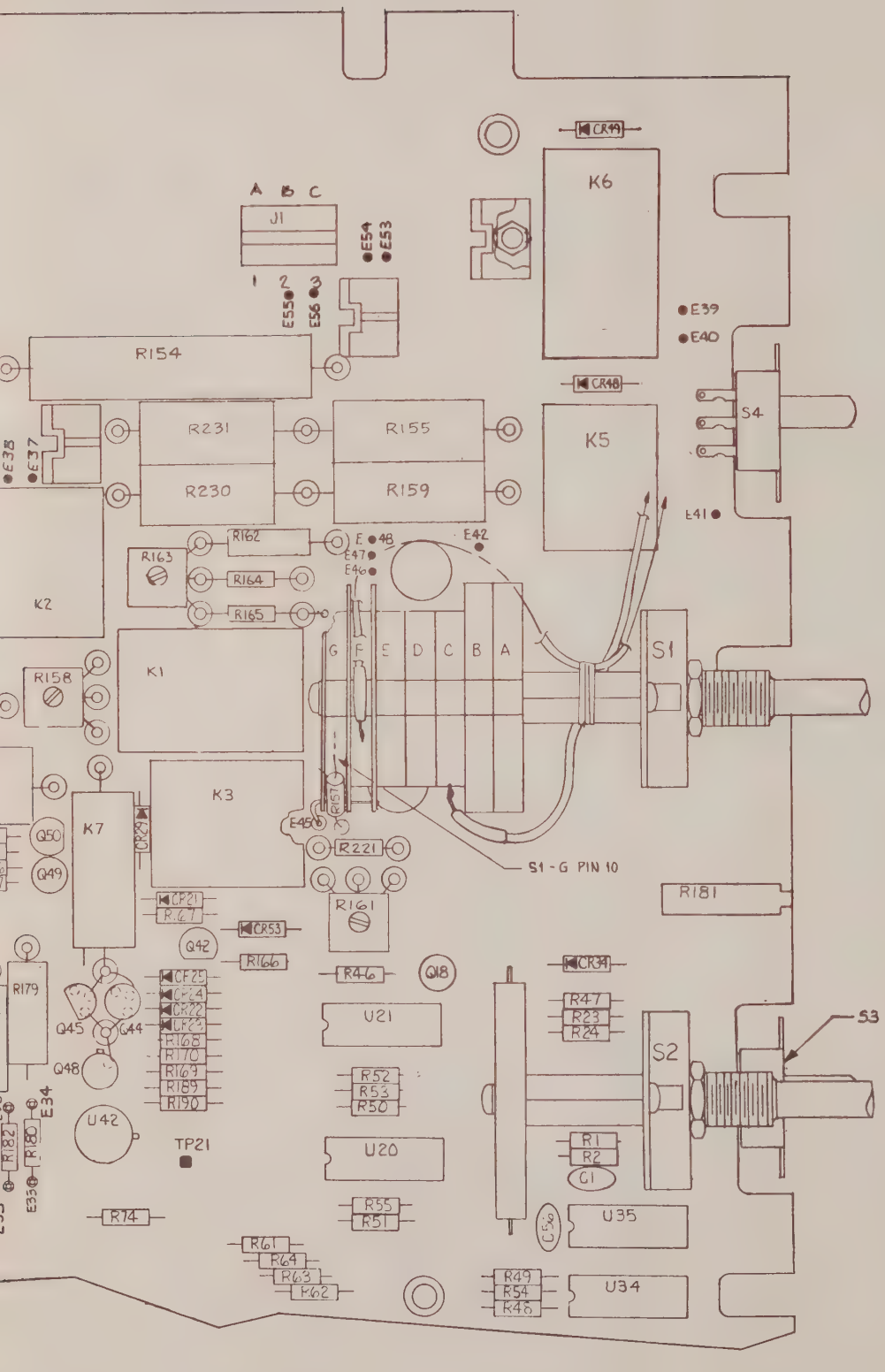
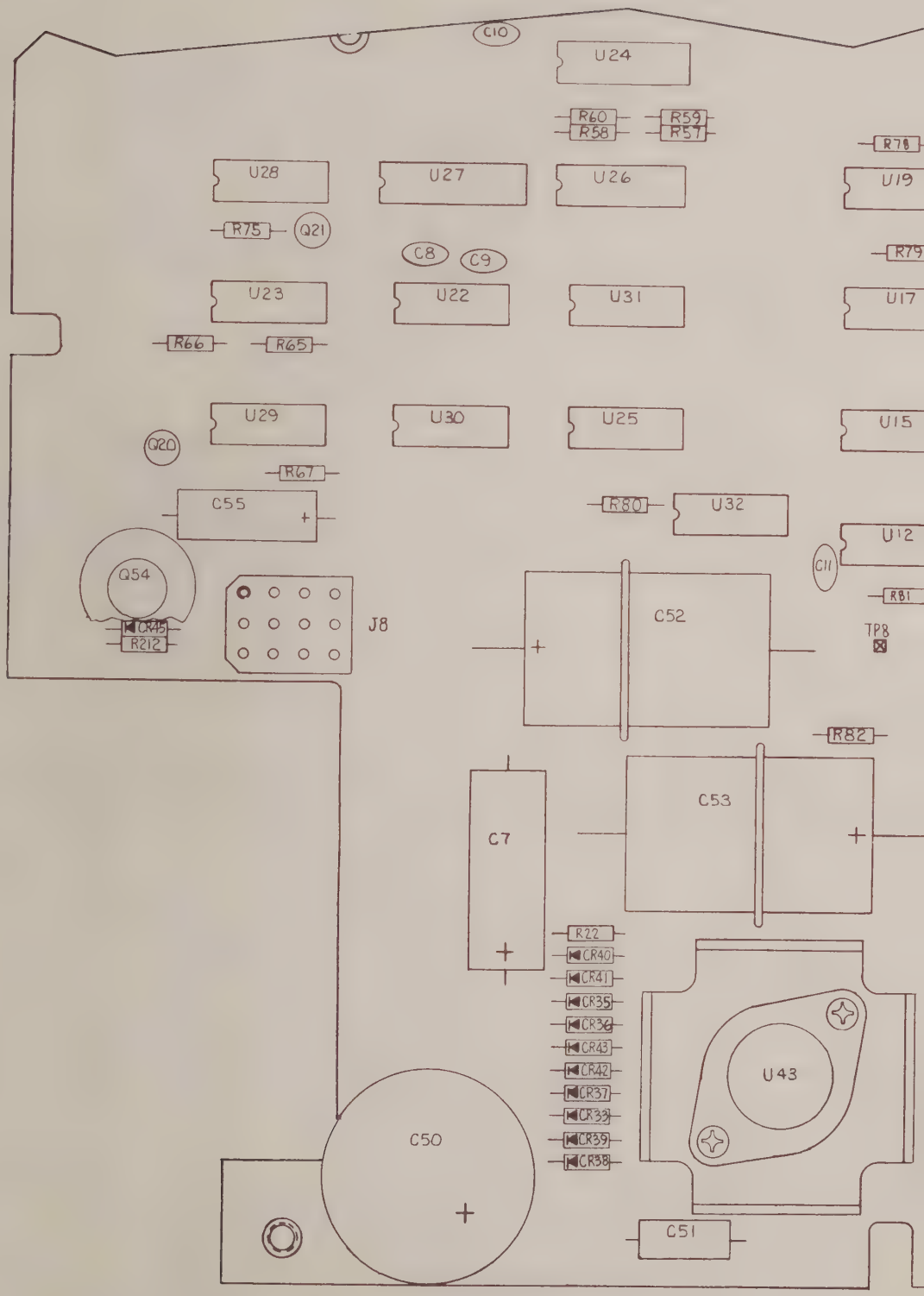


Figure 6.1 - Layout, Main Logic


A B C
J1
1 2 3
E54
E53
E55
E56
CR49
K6
E39
E40
R154
CR48
S4
R231
R155
K5
R230
R159
E38
E37
E41
R162
E48
E42
R163
E47
R164
E46
R165
K2
G F E D C B A
S1
R158
K1
K3
K7
CR29
Q50
Q49
E45
R221
S1 - G PIN 10
R181
CR21
R67
CR53
R161
Q42
R166
R46
Q18
CR34
R179
R47
R23
R24
S2
S3
Q45
Q44
Q48
CR22
CR23
R168
R170
R169
R189
R190
U21
R52
R53
R50
E34
U42
TP21
U20
R1
R2
C1
R182
R180
R55
R51
C56
U35
R74
R61
R64
R63
R62
R49
R54
R48
U34


C10
U24
R60
R58
R59
R57
R78
U28
U27
U26
U19
R75
Q21
C8
C9
R79
U23
U22
U31
U17
R66
R65
U29
U30
U25
U15
Q20
R67
C55
R80
U32
U12
C11
Q54
J8
C52
TP8
R81
CR45
R212
R82
C53
C7
R22
CR40
CR41
CR35
CR36
CR43
CR42
CR37
CR33
CR39
CR38
U43
C50
C51

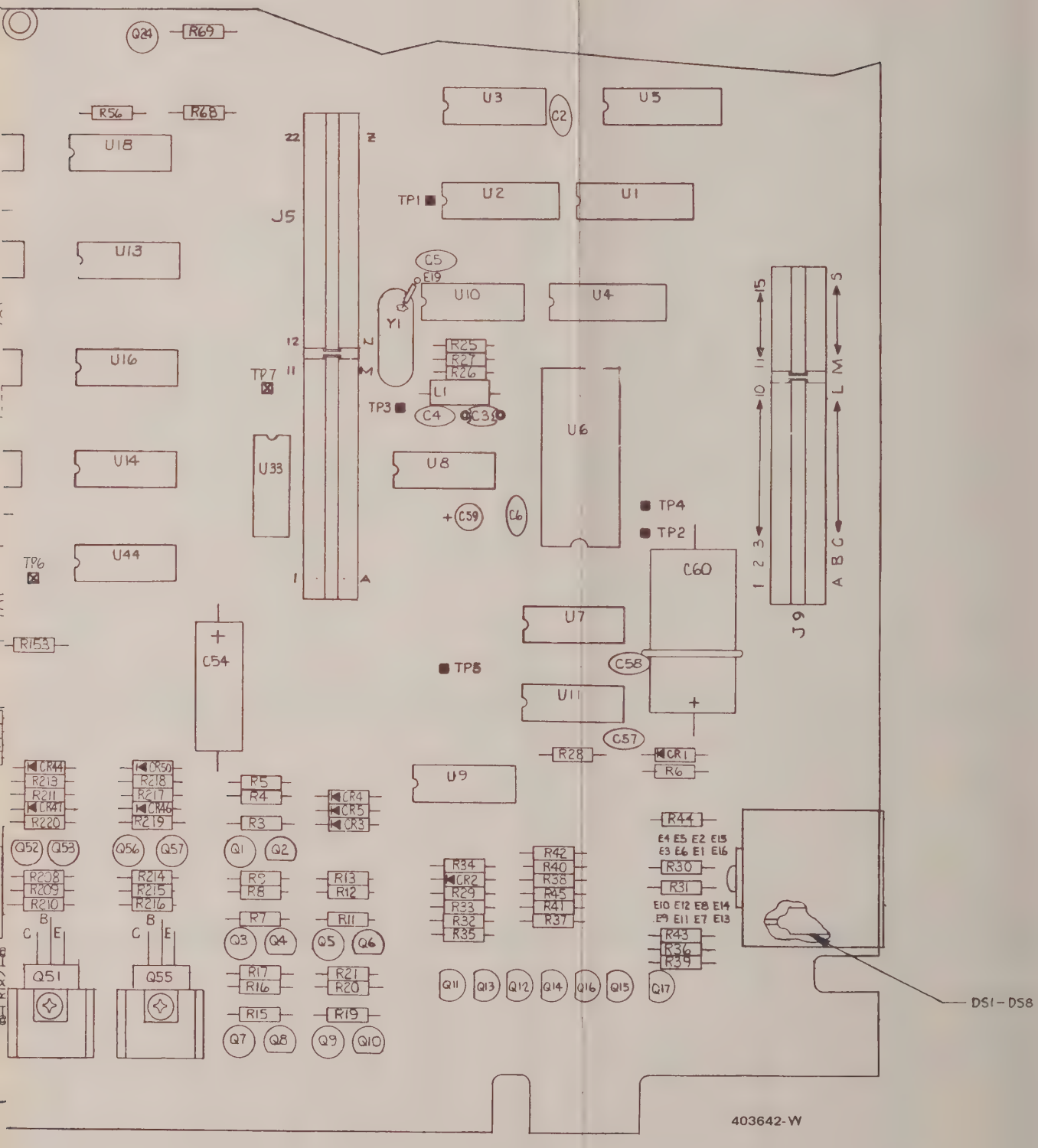
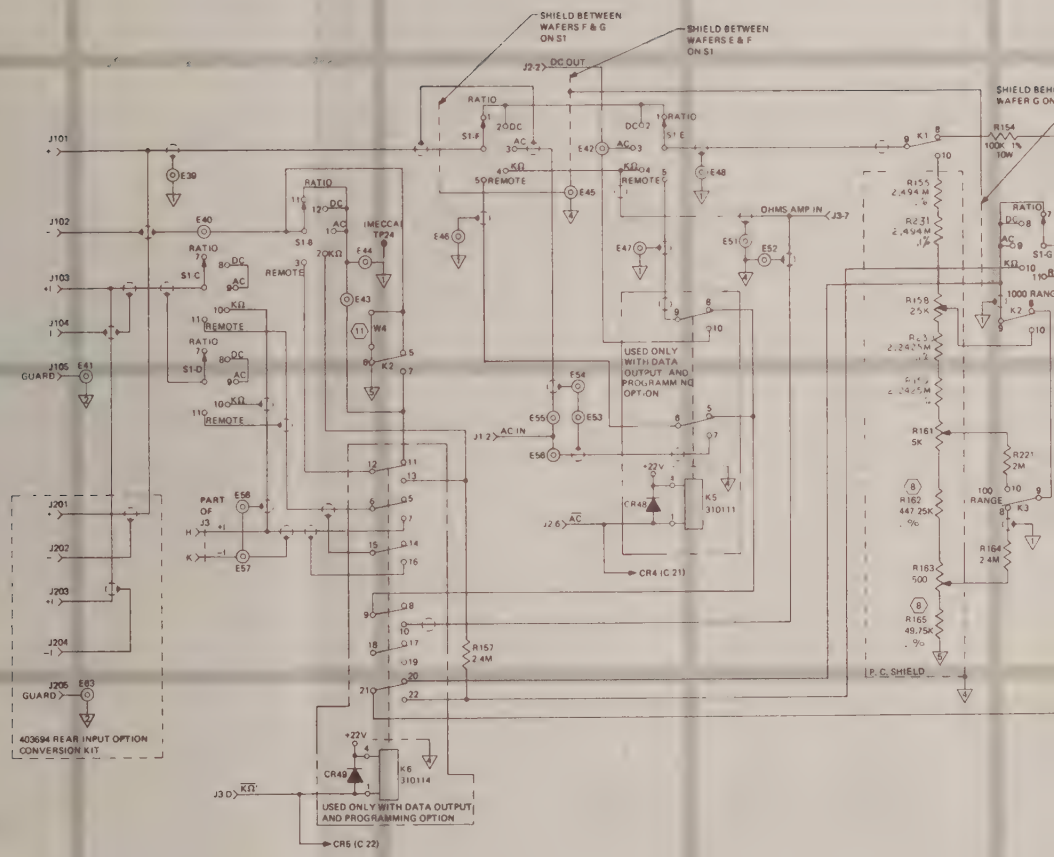
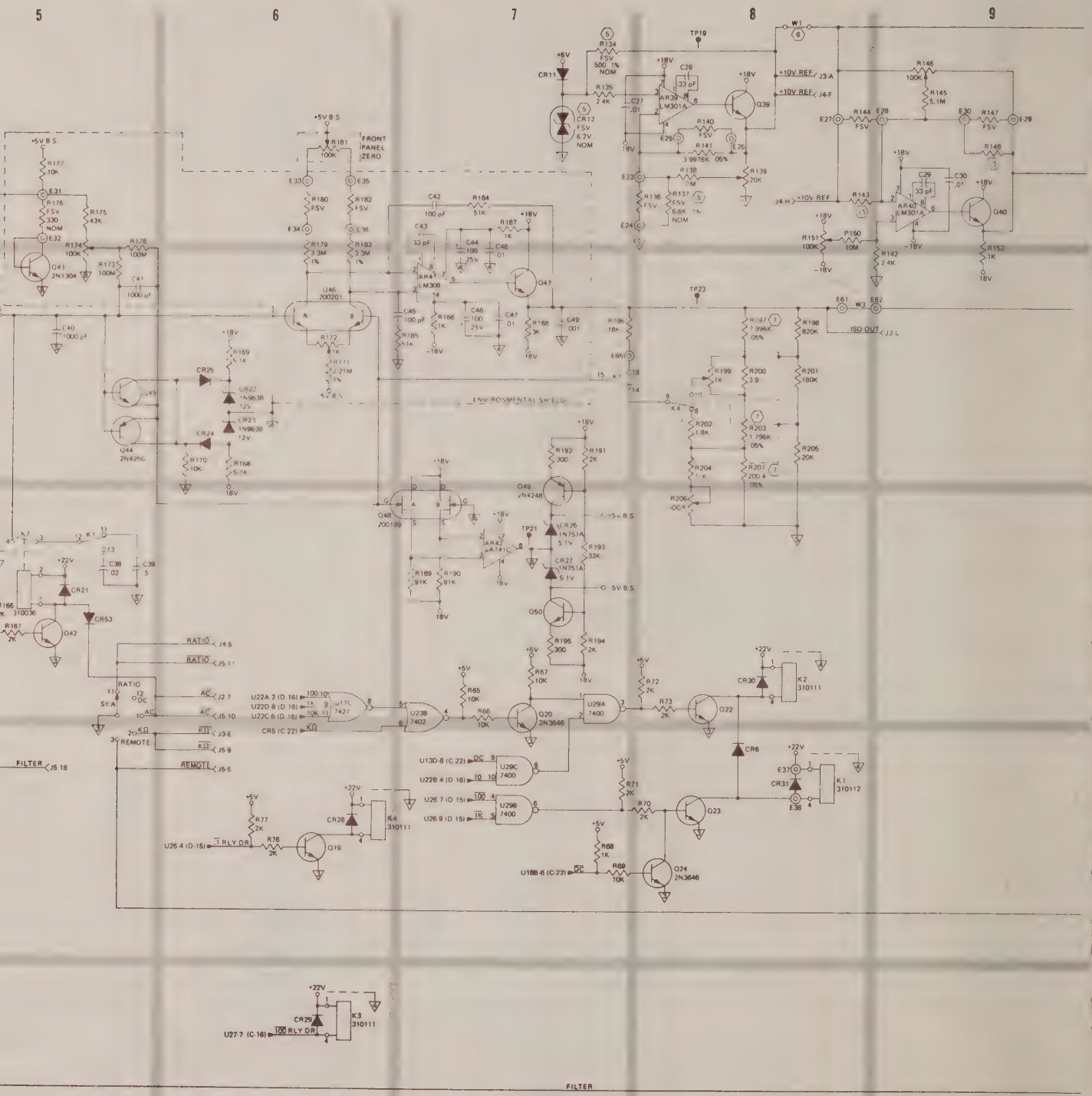
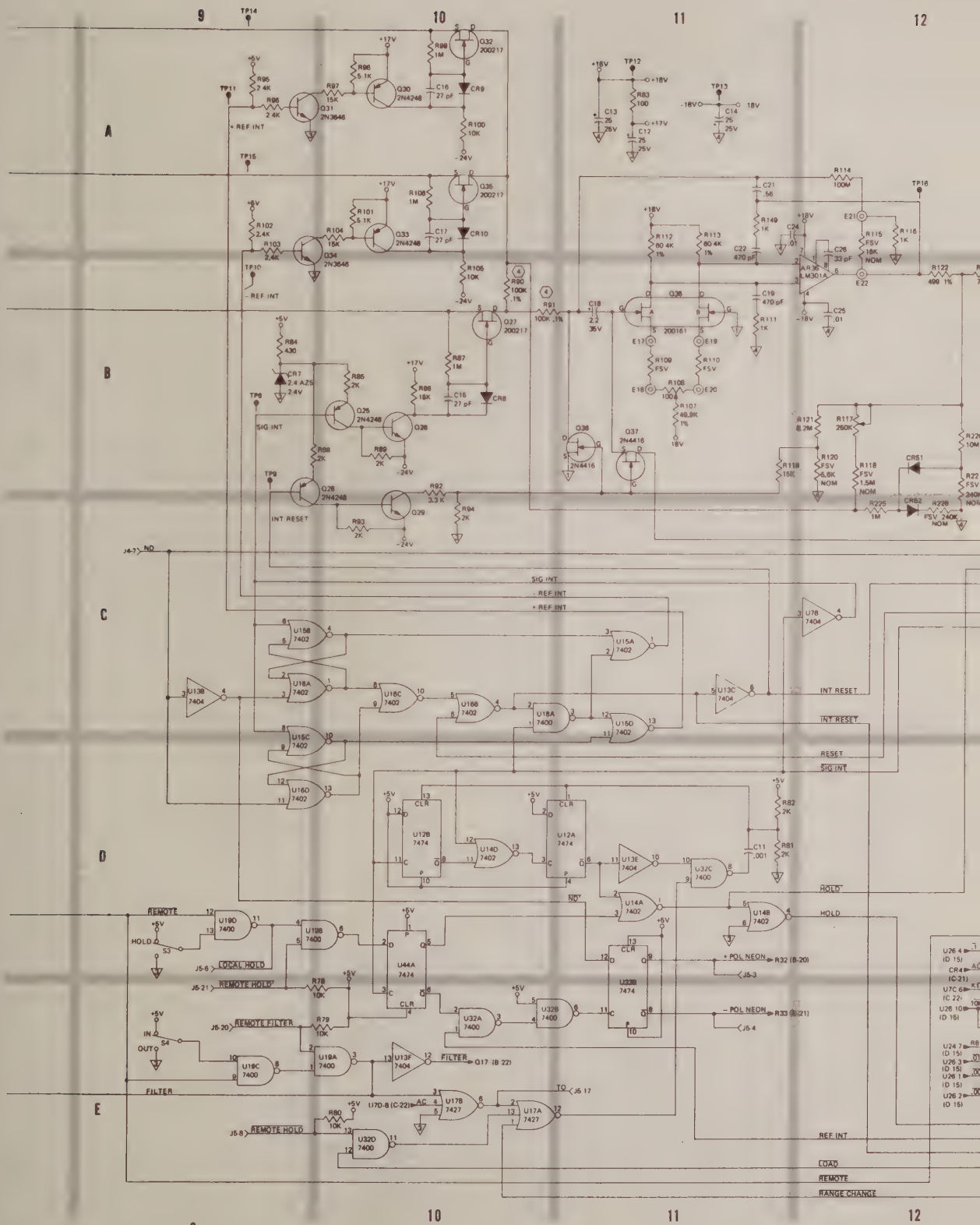


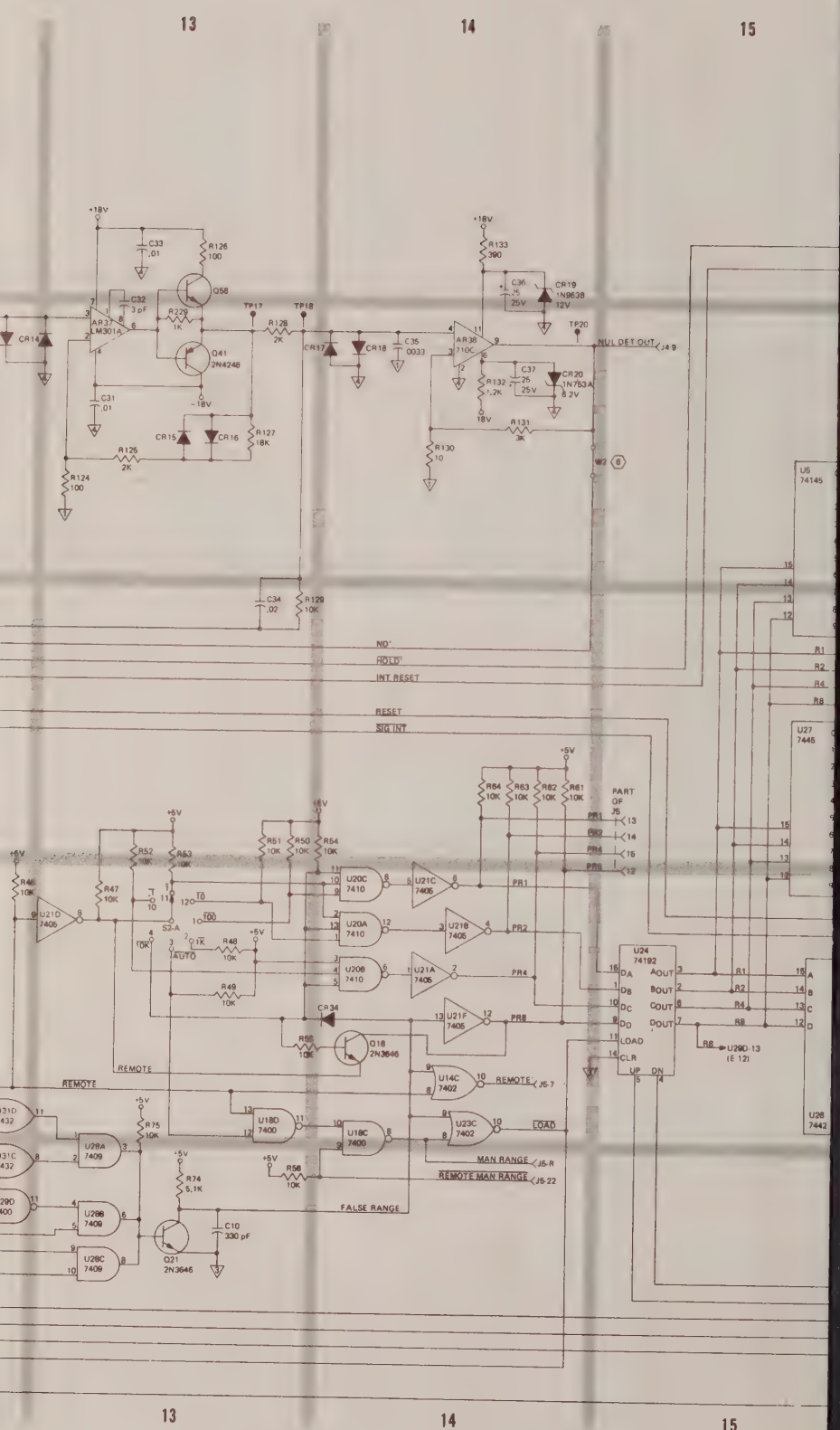
Figure 6.1 - Layout, Main Logic continued

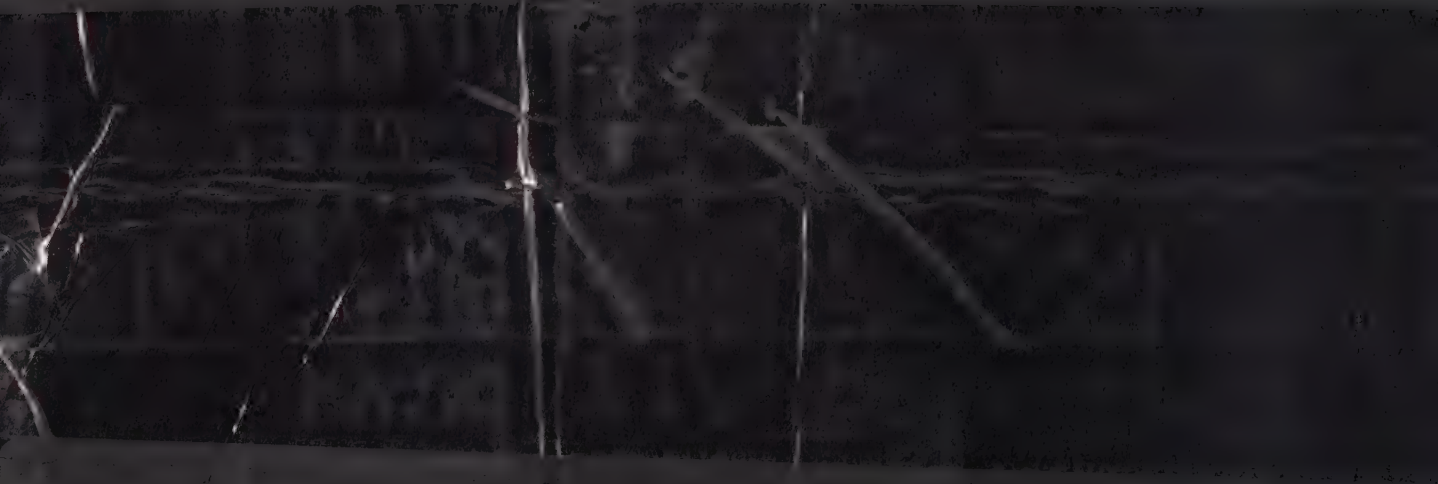

SHIELD BETWEEN WAFERS F & G ON S1
SHIELD BETWEEN WAFERS E & F ON S1
J2-7 DC OUT
RATIO
S1-B
20DC
AC
DCO2
RATIO
S1-E
E42
AC
03
K1
R154 100K 1% 10W
J101
E39
RATIO
S1-A
E40
AC
IMECCA1 TP24
E44
20KΩ
3 REMOTE
E43
W4
K2
J102
J103
J104
J105 E41 GUARD
RATIO S1-C
RATIO S1-D
10KΩ REMOTE
E45
E46
E47
E48
OHMS AMP IN J3-7
E51
E52
R155 2.494M
R231 2.494M
R158 25K
R161 5K
R162 447.25K
R163 500
R165 49.75K
R221 2M
R164 2.4M
1000 RANGE
100 RANGE
K3
P. C. SHIELD
USED ONLY WITH DATA OUTPUT AND PROGRAMMING OPTION
E54
E55
E53
AC IN J1-2
E56
+22V
CR48
K5 310111
J2-6 AC
CR4 (C 21)
J201
J202
J203
J204
J205 E83 GUARD
403694 REAR INPUT OPTION CONVERSION KIT
PART OF J3
E58
E57
R157 2.4M
+22V
CR49
K6 310114
J3-D KΩ
USED ONLY WITH DATA OUTPUT AND PROGRAMMING OPTION
CR5 (C 22)



igure 6.2 - Schematic, Main Logic


9
10
11
12
A
B
C
D
E
TP14
TP11
TP15
TP10
TP8
TP9
TP12
TP13
TP16
+17V
+5V
+18V
-18V
-24V
+ REF INT
- REF INT
SIG INT
INT RESET
J4-7 ND
Q32 2N0217
Q30 2N4248
Q31 2N3646
Q35 2N0217
Q33 2N4248
Q34 2N3646
Q27 2N0217
Q26 2N4248
Q28 2N4248
Q29
Q36 2N4416
Q37 2N4416
Q38 2N0161
CR7 2.4 AZ5
CR9
CR10
CR8
CR51
CR52
AR36 LM301A
R95 2.4K
R96 2.4K
R97 15K
R98 5.1K
R99 1M
R100 10K
R101 5.1K
R102 2.4K
R103 2.4K
R104 15K
R105 10K
R108 1M
R84 430
R85 2K
R86 15K
R87 1M
R88 2K
R89 2K
R92 3.3K
R93 2K
R94 2K
R90 100K .1%
R91 100K .1%
R83 100
R112 60.4K 1%
R113 60.4K 1%
R149 1K
R111 1K
R109 FSV
R110 FSV
R108 100K
R107 49.9K 1%
R114 100W
R115 FSV 18K NOM
R116 1K
R122 499 1%
R121 8.2M
R117 250K
R120 FSV 6.8K NOM
R118 FSV 1.5M NOM
R118 15K
R225 1M
R226 FSV 240K NOM
C16 27 pF
C17 27 pF
C15 27 pF
C18 2.2 35V
C19 470 pF
C21 .56
C22 470 pF
C24 .01
C26 33 pF
C25 .01
C13 25 25V
C12 25 25V
C14 25 25V
C11 .001
U15B 7402
U16A 7402
U16C 7402
U16B 7402
U15C 7402
U16D 7402
U15A 7402
U18A 7400
U15D 7402
U13C 7404
U13B 7404
U13A 7404
U7B 7404
U12B 7474
U14D 7402
U12A 7474
U13E 7404
U32C 7400
U14A 7402
U14B 7402
U44A 7474
U33B 7474
U32A 7400
U32B 7400
U19B 7400
U19C 7400
U19A 7400
U13F 7404
U32D 7400
U17B 7427
U17A 7427
REMOTE
HOLD
LOCAL HOLD
REMOTE HOLD
REMOTE FILTER
FILTER
S3
S4
IN
OUT
+ POL NEON
- POL NEON
R32 (B-20)
R33 (B-21)
J5-3
J5-4
J5-6
J5-21
J5-20
J5-8
R78 10K
R79 10K
R80 10K
Q17 (B-22)
U17D-8 (C-22)
TO J5 17
REF INT
LOAD
REMOTE
RANGE CHANGE


13
14
15
+18V
C33 .01
R126 100
Q58
C32 3 pF
R229 1K
TP17
TP18
R128 2K
AR37 LM301A
Q41 2N4248
C31 .01
-18V
CR15
CR16
R127 18K
R125 2K
R124 100
CR14
CR17
CR18
C35 0033
AR38 710C
R133 390
C36 25 25V
CR19 1N963B 12V
TP20
NVL DET OUT J4-9
R132 1.2K
C37 25 25V
CR20 1N753A 6.2V
R131 3K
R130 10
W2
C34 .02
R129 10K
U5 74145
ND'
HOLD'
INT RESET
RESET
SIG INT
R64 10K
R63 10K
R62 10K
R61 10K
PART OF J5
PR1
PR2
PR4
PR8
R52 10K
R53 10K
R51 10K
R50 10K
R54 10K
R46 10K
R47 10K
U21D 7406
U20C 7410
U21C 7405
U20A 7410
U21B 7405
U20B 7410
U21A 7405
U21F 7405
TO
TO'
120
S2-A
AUTO
Q1R
R48 10K
R49 10K
CR34
R55 10K
Q18 2N3646
REMOTE
U14C 7402
REMOTE J6-7
U18D 7400
U18C 7400
U23C 7402
LOAD
MAN RANGE J6-R
REMOTE MAN RANGE J6-22
R56 10K
R75 10K
R74 5.1K
C10 330 pF
Q21 2N3646
FALSE RANGE
U28A 7409
U28B 7409
U28C 7409
U24 74192
DA
DB
DC
DD
LOAD
CLR
UP
DN
AOUT
BOUT
COUT
DOUT
R8 → U29D-13 (E 12)
U27 7445
U26 7442



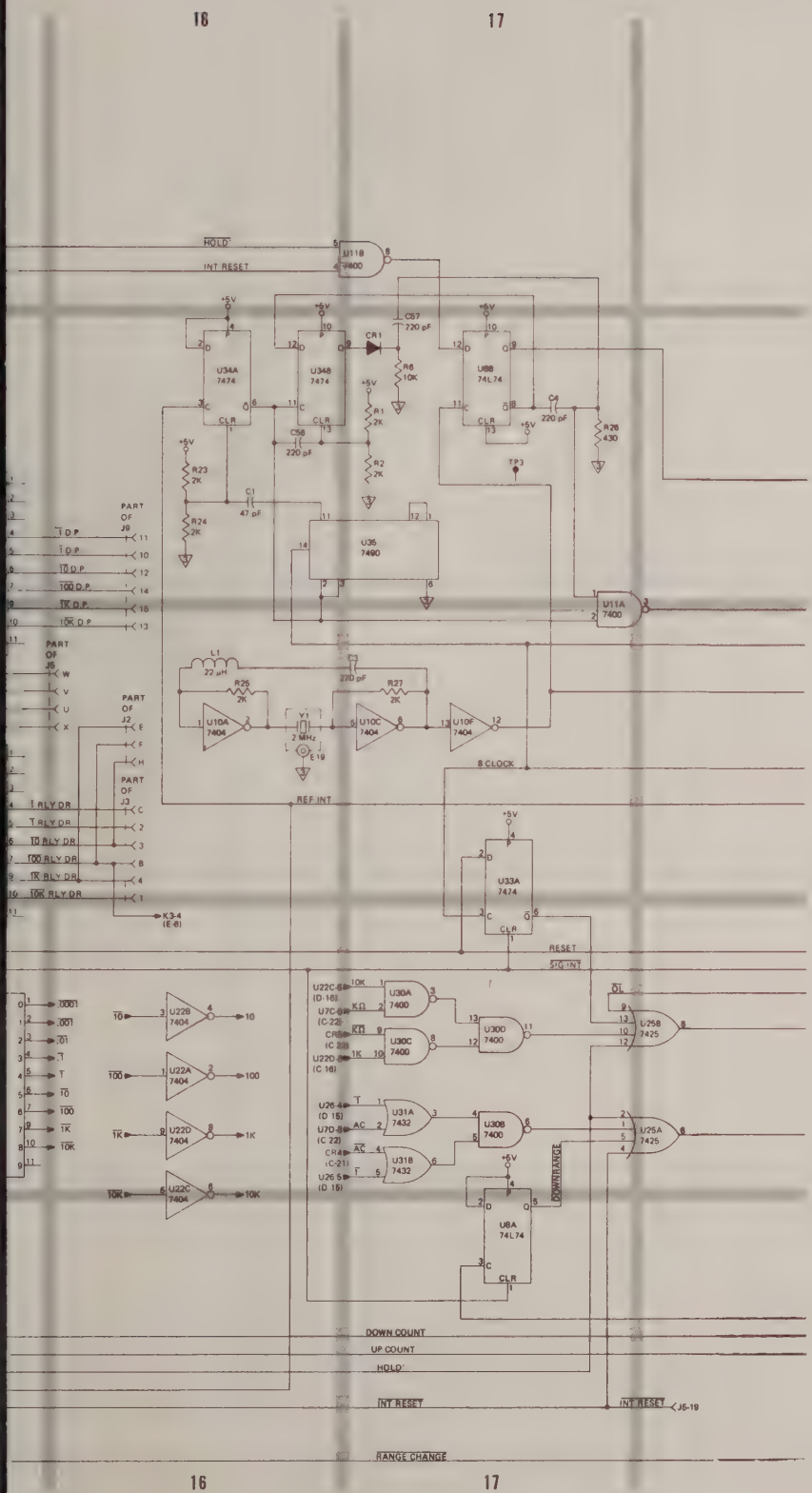
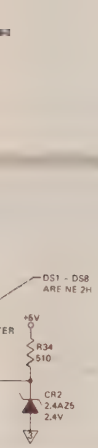


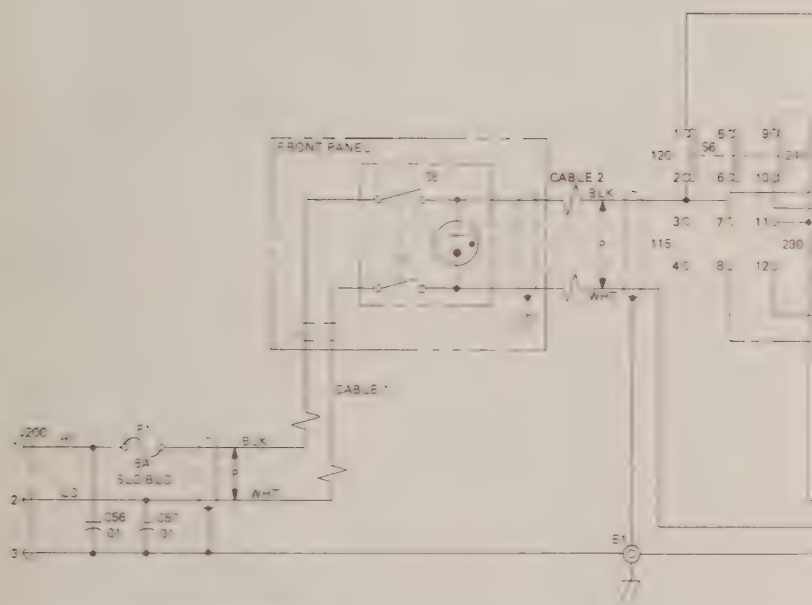
Figure 6.2 - Schematic, Main Logic

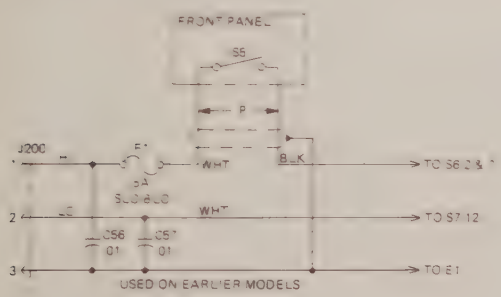


13. RESISTOR SET 010896
12. TRANSISTORS ARE 200200
11. ASSY 403642
10. RELAYS ARE SHOWN IN NON ENERGIZED POSITION
9. GROUNDS INDICATED AS FOLLOWS
   - ISOLATOR COMMON
   - ANALOG COMMON
   - DIGITAL COMMON
   - GUARD
   - MECCA
8. MATCHED RESISTOR SET 010772
7. RESISTORS R197, R203, & R207 ARE MATCHED SET 020652
6. W1 & W2 REMOVED WHEN RATIO OPTION IS INSTALLED
5. RESISTORS R134 & R137 AND CR12 ARE PART OF ZENER REFERENCE KIT 403294
4. RESISTORS R90 & R91 ARE MATCHED PAIR, RESISTOR SET 010741
3. DIODES ARE D18
2. CAPACITORS ARE IN MFD
1. RESISTORS ARE IN OHMS, ±5%, 1/4W

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.2 - Schematic, Main Logic





NOTE UNLESS OTH
1 RESISTORS ARE
2 CAPACITORS AR
3 DIODES ARE SO

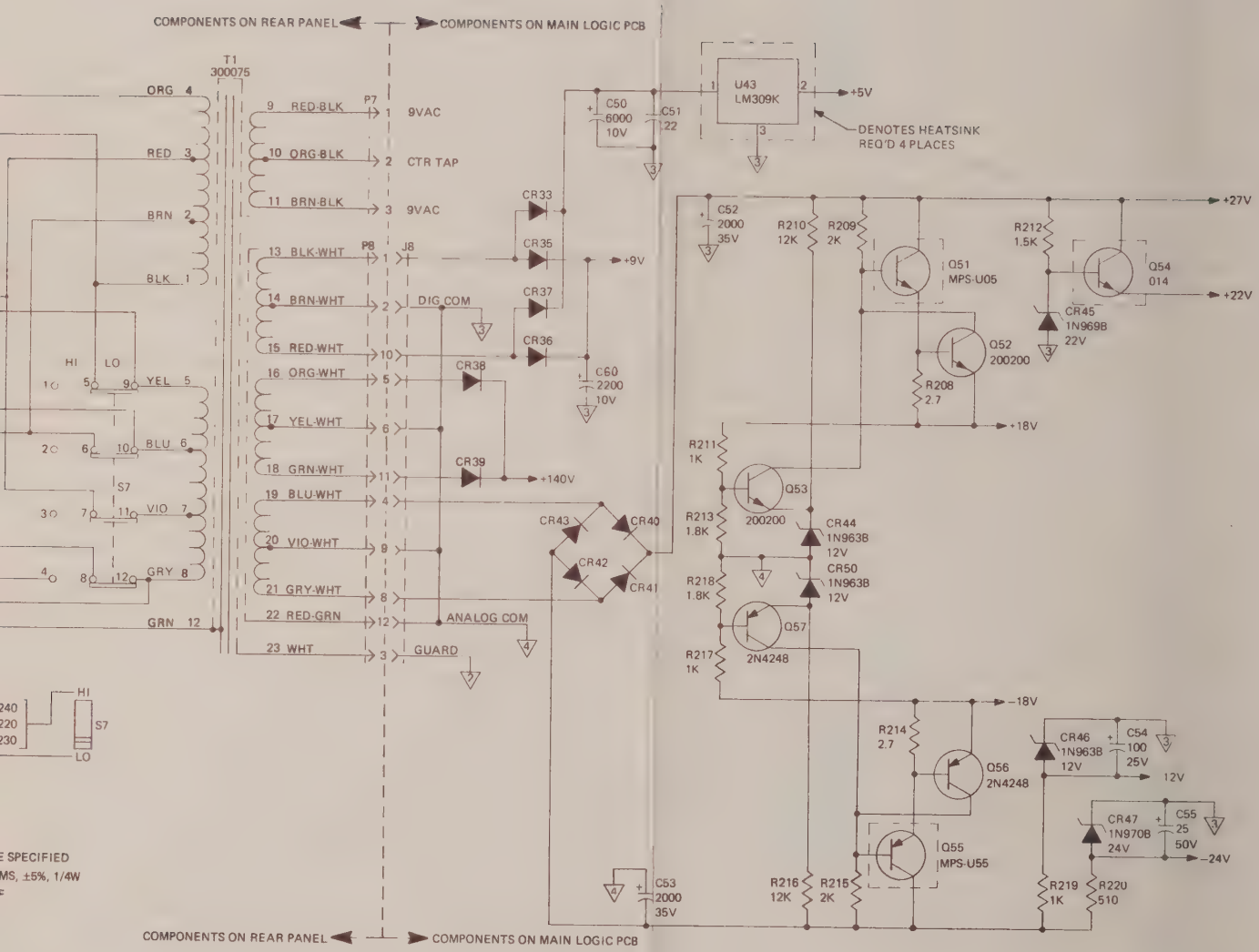
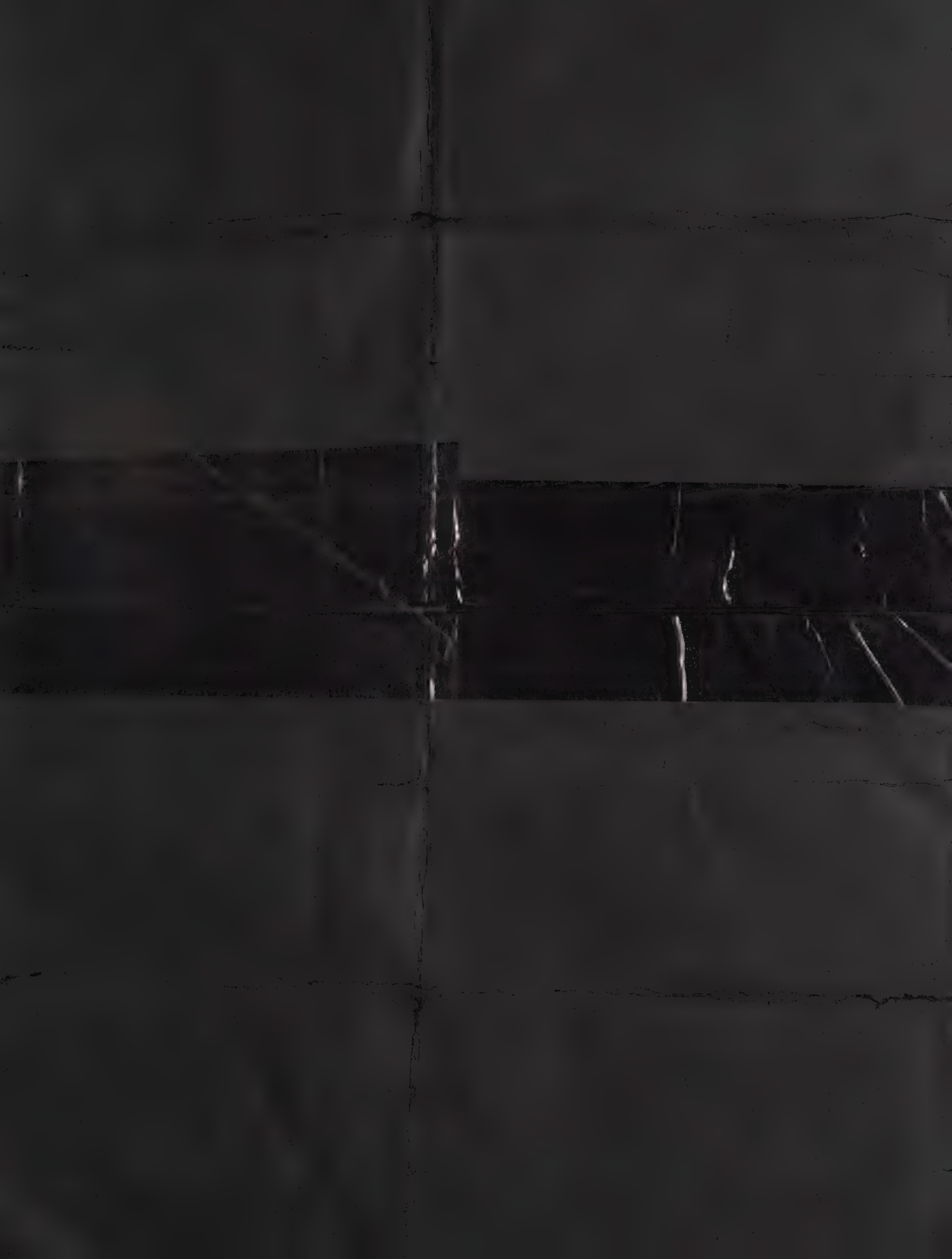


Figure 6.3 - Schematic, Power Supply



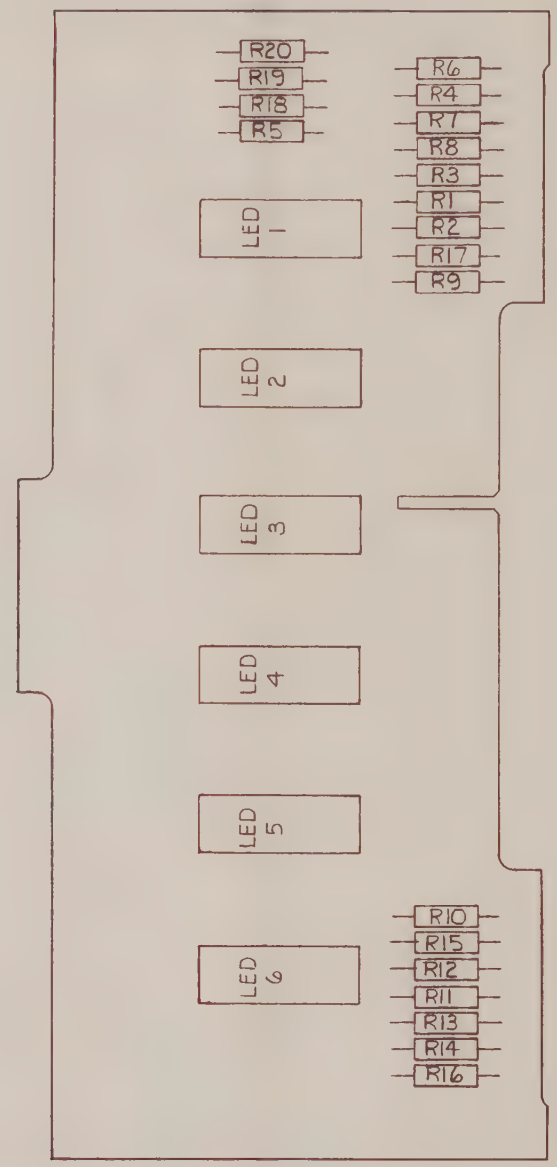
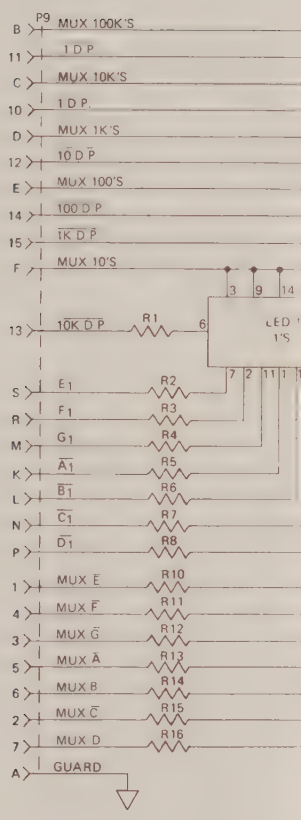
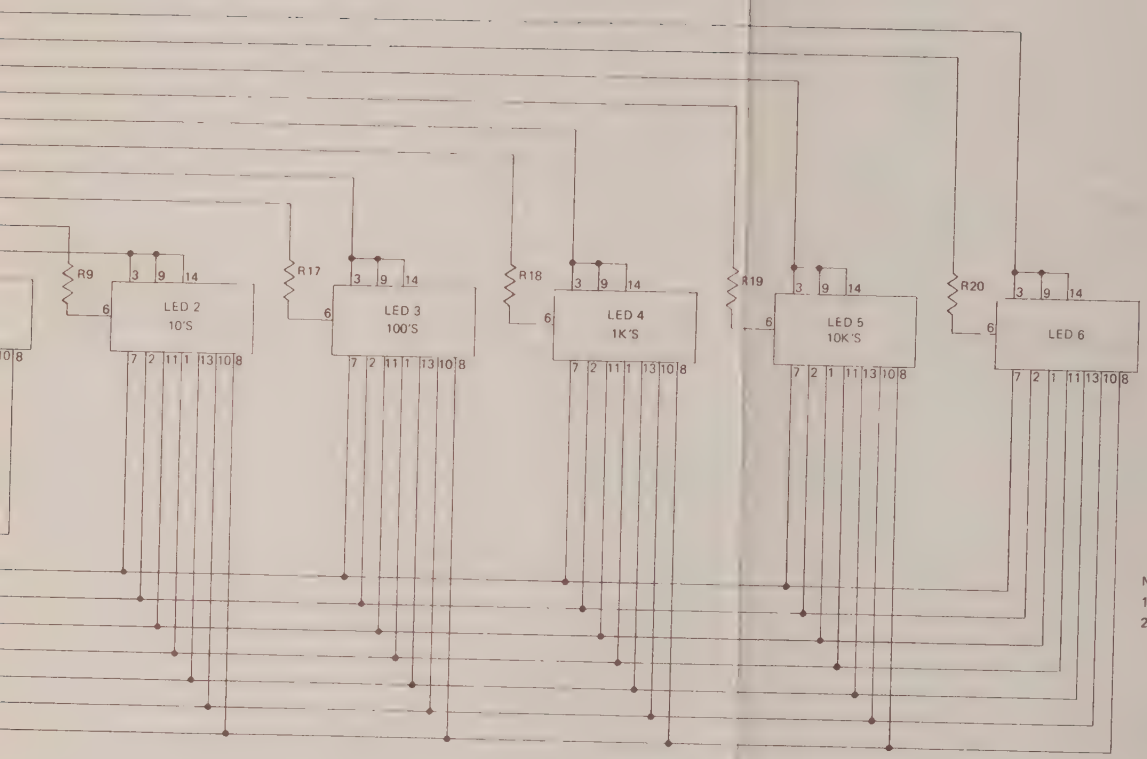


Figure 6.4 - Layout, Display

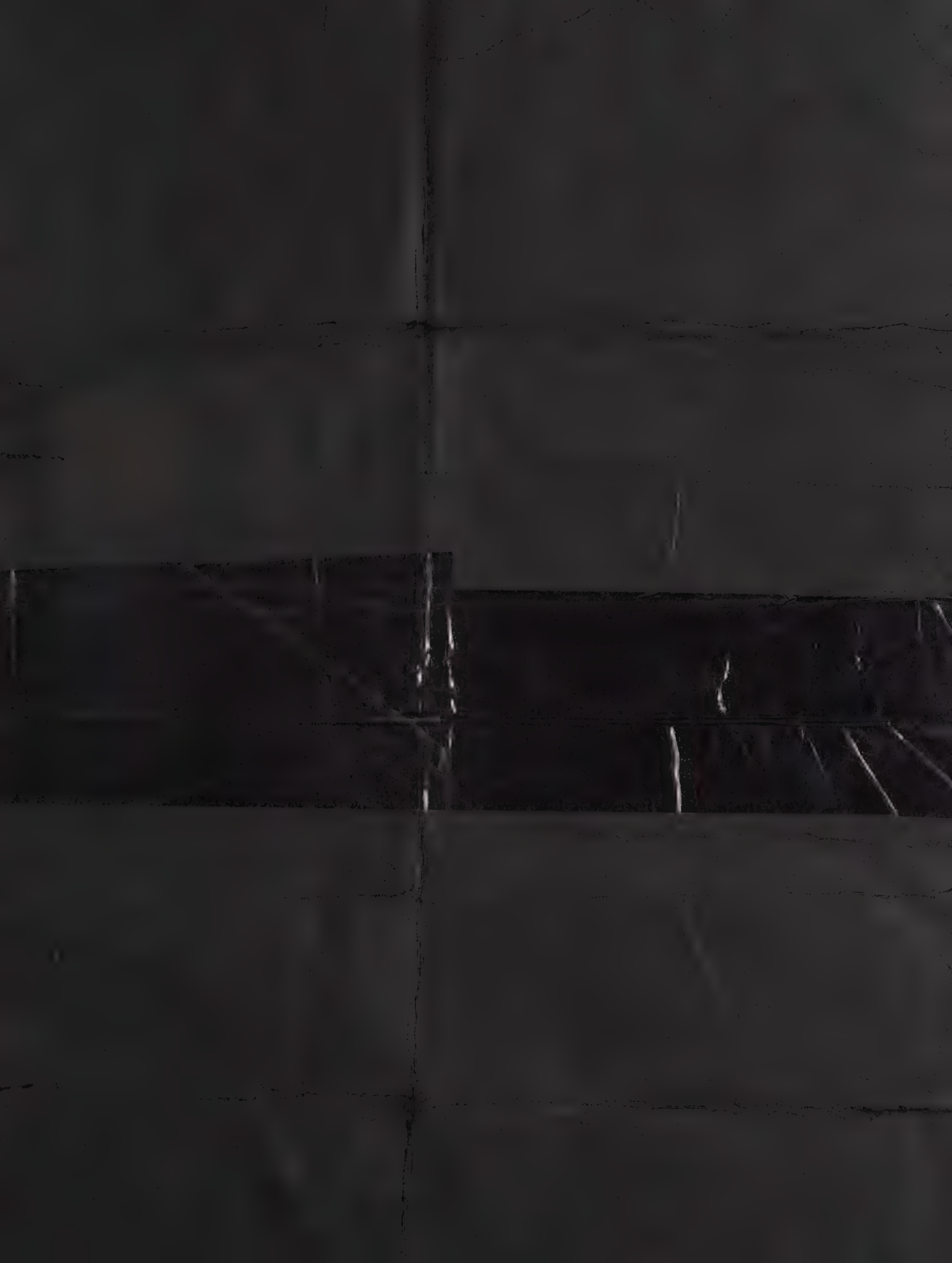

P9
B
MUX 100K'S
11
1 D P
C
MUX 10K'S
10
1 D P
D
MUX 1K'S
12
10 D P
E
MUX 100'S
14
100 D P
15
1K D P
F
MUX 10'S
3
9
14
13
10K D P
R1
6
LED
1'S
7
2
11
1
S
E1
R2
R
F1
R3
M
G1
R4
K
A1
R5
L
B1
R6
N
C1
R7
P
D1
R8
1
MUX E
R10
4
MUX F
R11
3
MUX G
R12
5
MUX A
R13
6
MUX B
R14
2
MUX C
R15
7
MUX D
R16
A
GUARD

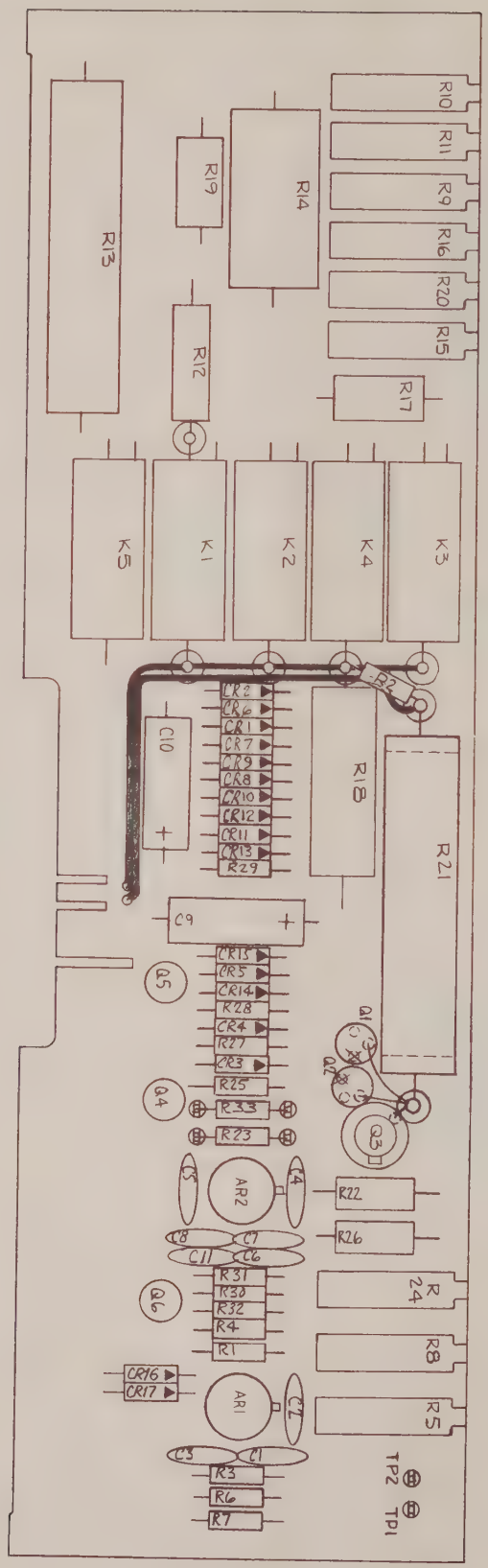


NOTE: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE 220Ω, ±5%, 1/4W
2. LED'S ARE 210060

ASSY 403809-C
SCHEM 432072 A

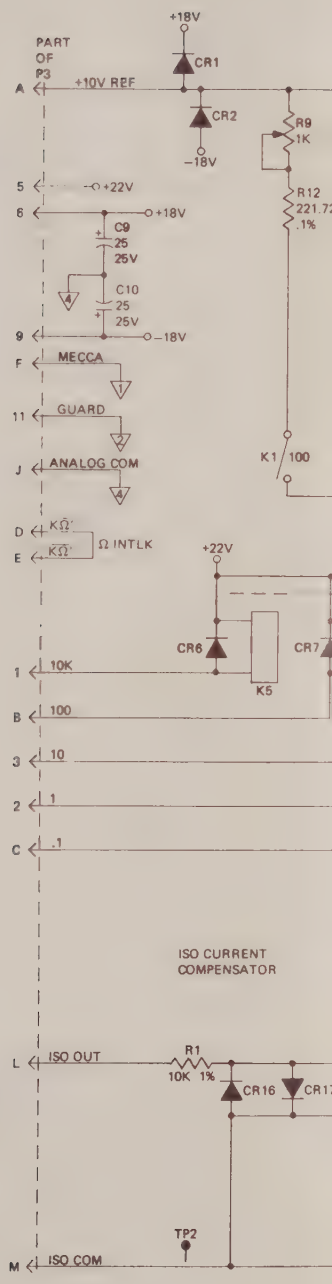
Figure 6.5 - Schematic, Display

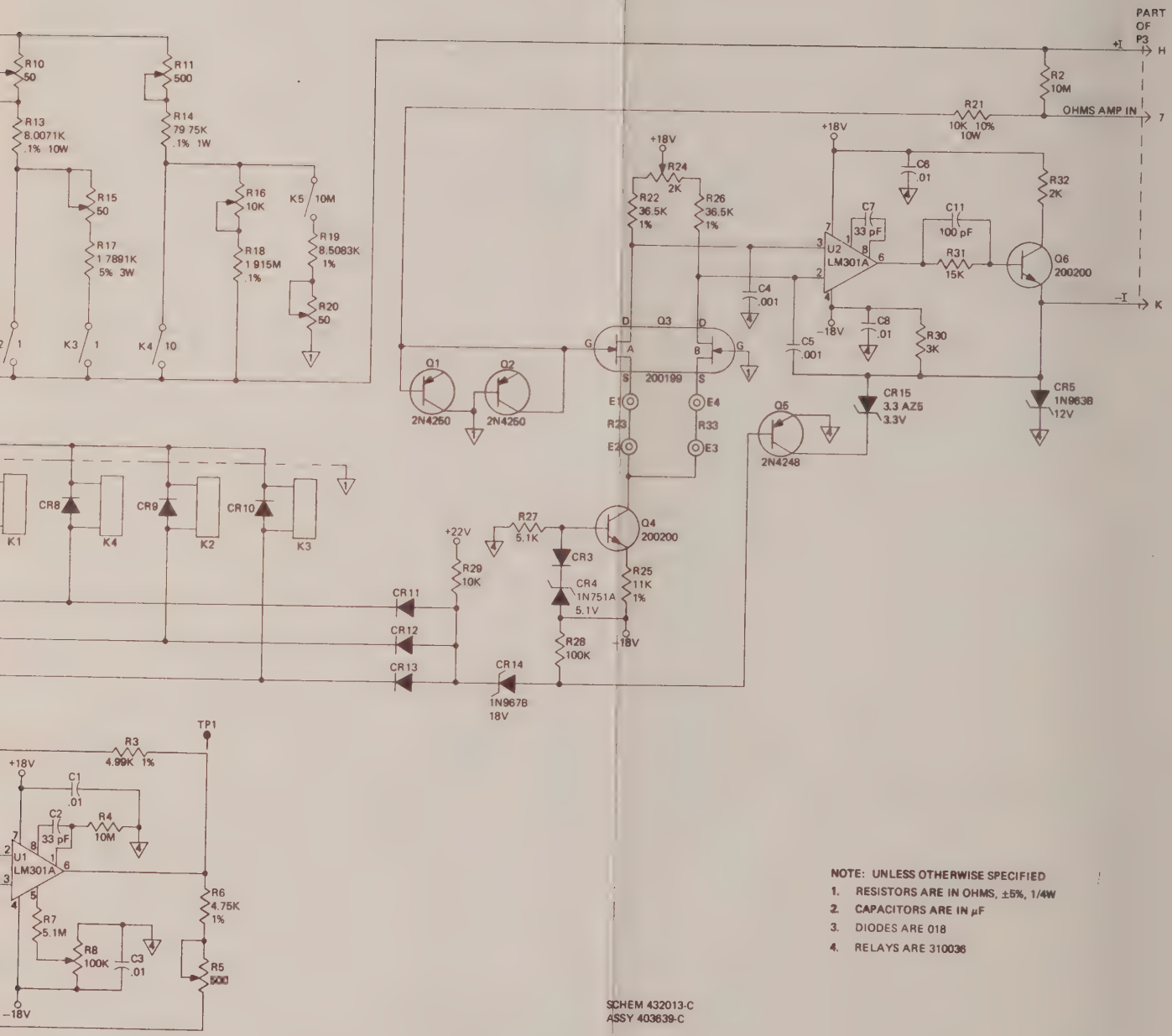




403639-C

Figure 6.6 - Layout, Ohms Converter

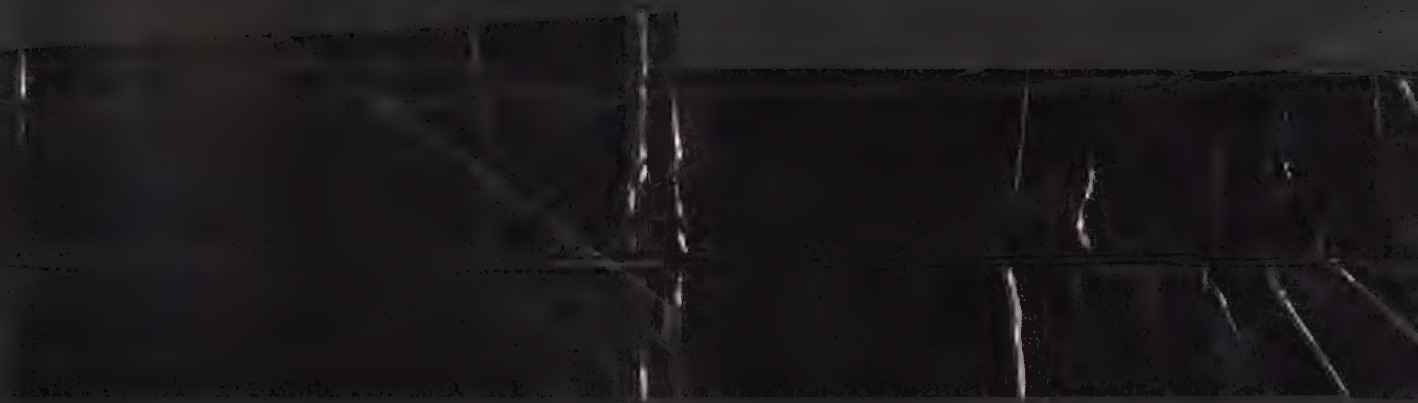

+18V
PART OF P3
CR1
A
+10V REF
CR2
R9 1K
-18V
5
+22V
6
+18V
R12 221.7 .1%
C9 25 25V
C10 25 25V
9
-18V
F
MECCA
11
GUARD
J
ANALOG COM
K1
100
D
KΩ
E
KΩ
Ω INTLK
+22V
CR6
CR7
1
10K
K5
B
100
3
10
2
1
C
.1
ISO CURRENT COMPENSATOR
L
ISO OUT
R1 10K 1%
CR16
TP2
M
ISO COM

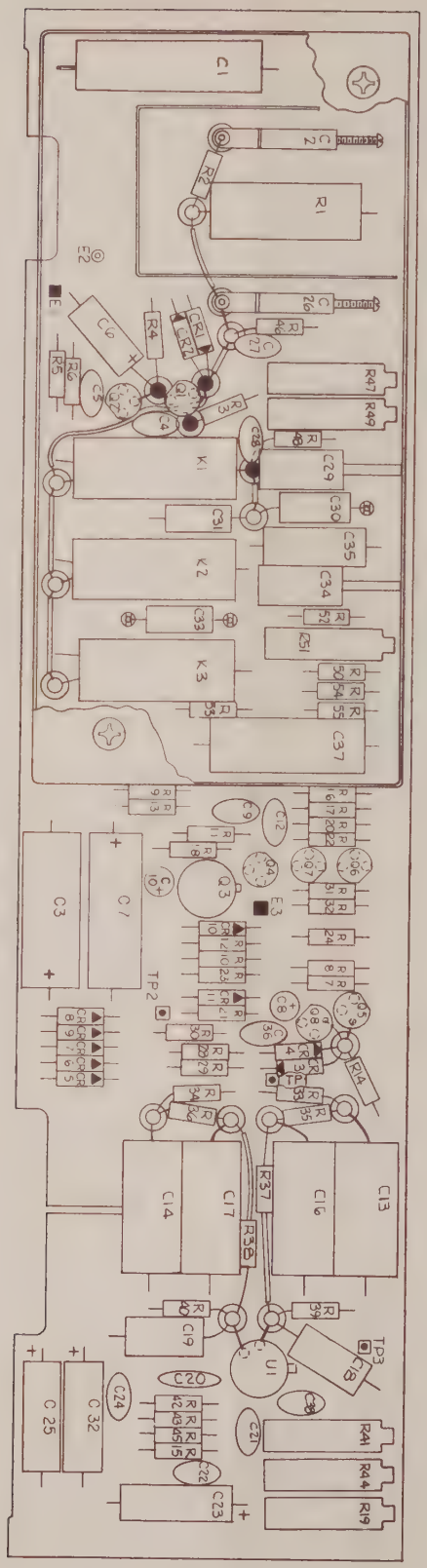


NOTE: UNLESS OTHERWISE SPECIFIED
1. RESISTORS ARE IN OHMS, ±5%, 1/4W
2. CAPACITORS ARE IN μF
3. DIODES ARE 018
4. RELAYS ARE 310036

SCHEM 432013-C
ASSY 403639-C

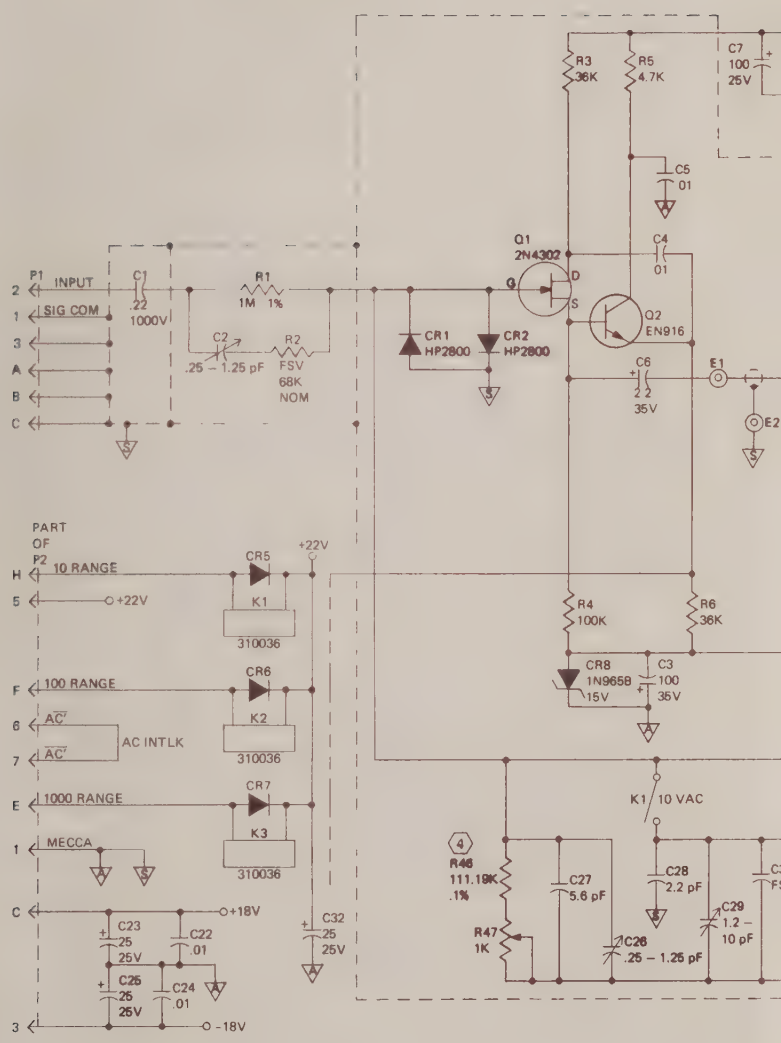
Figure 6.7 - Schematic, Ohms Converter

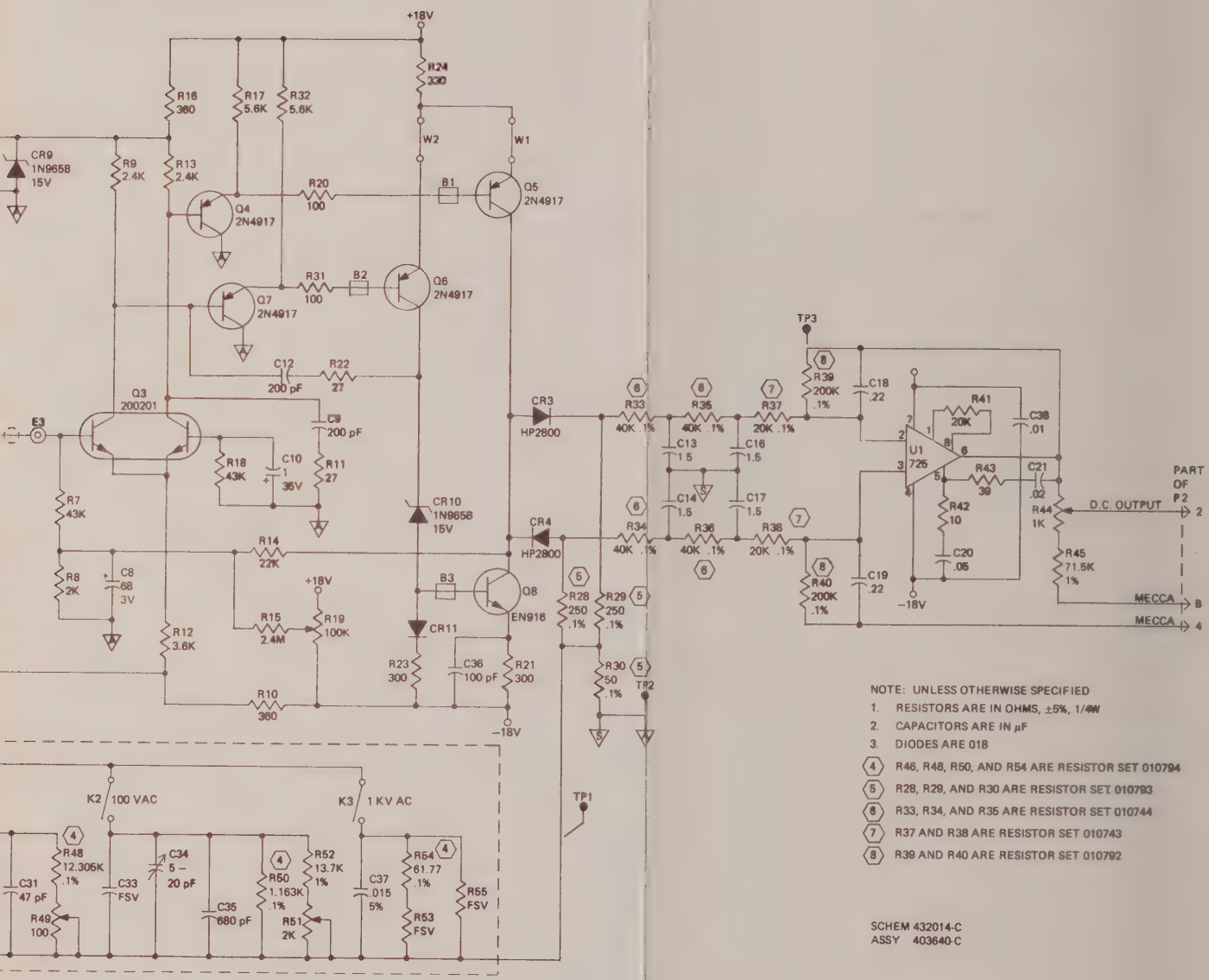




403640-C

Figure 6.8 - Layout, AC Converter


P1
INPUT
SIG COM
C1
.22
1000V
R1
1M 1%
C2
.25 – 1.25 pF
R2
FSV
68K
NOM
CR1
HP2800
CR2
HP2800
Q1
2N4302
Q2
EN916
R3
36K
R5
4.7K
C7
100
25V
C5
01
C4
01
C6
2.2
35V
E1
E2
PART
OF
P2
10 RANGE
+22V
CR5
K1
310036
100 RANGE
CR6
K2
310036
AC INTLK
1000 RANGE
CR7
K3
310036
MECCA
+18V
-18V
C23
25
25V
C22
.01
C25
25
25V
C24
.01
C32
25
25V
R4
100K
R6
36K
CR8
1N965B
15V
C3
100
35V
K1
10 VAC
R46
111.19K
.1%
R47
1K
C27
5.6 pF
C26
.25 – 1.25 pF
C28
2.2 pF
C29
1.2 –
10 pF

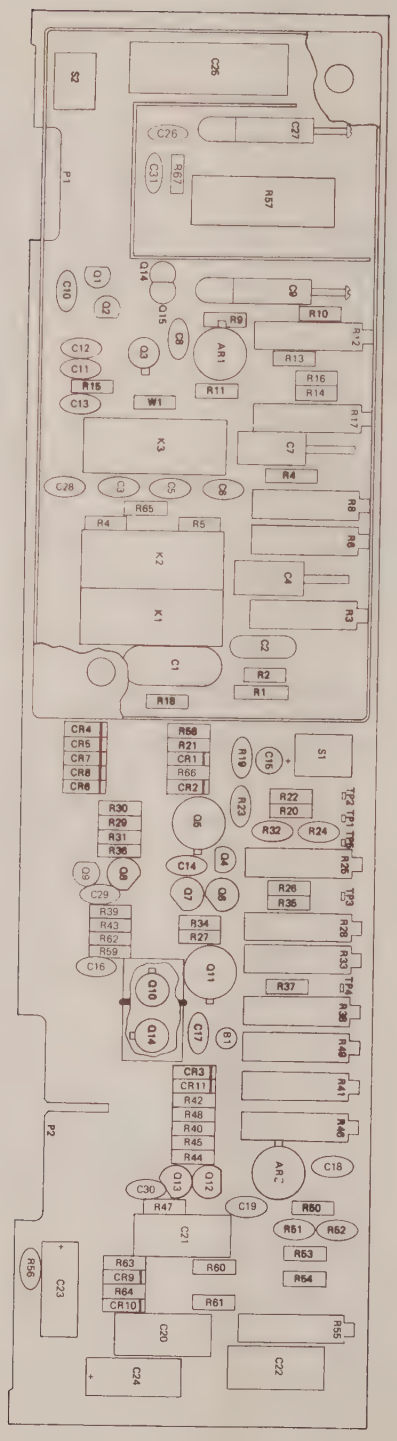


NOTE: UNLESS OTHERWISE SPECIFIED

1. RESISTORS ARE IN OHMS, ±5%, 1/4W
2. CAPACITORS ARE IN μF
3. DIODES ARE 018
4. R46, R48, R50, AND R54 ARE RESISTOR SET 010794
5. R28, R29, AND R30 ARE RESISTOR SET 010793
6. R33, R34, AND R35 ARE RESISTOR SET 010744
7. R37 AND R38 ARE RESISTOR SET 010743
8. R39 AND R40 ARE RESISTOR SET 010792

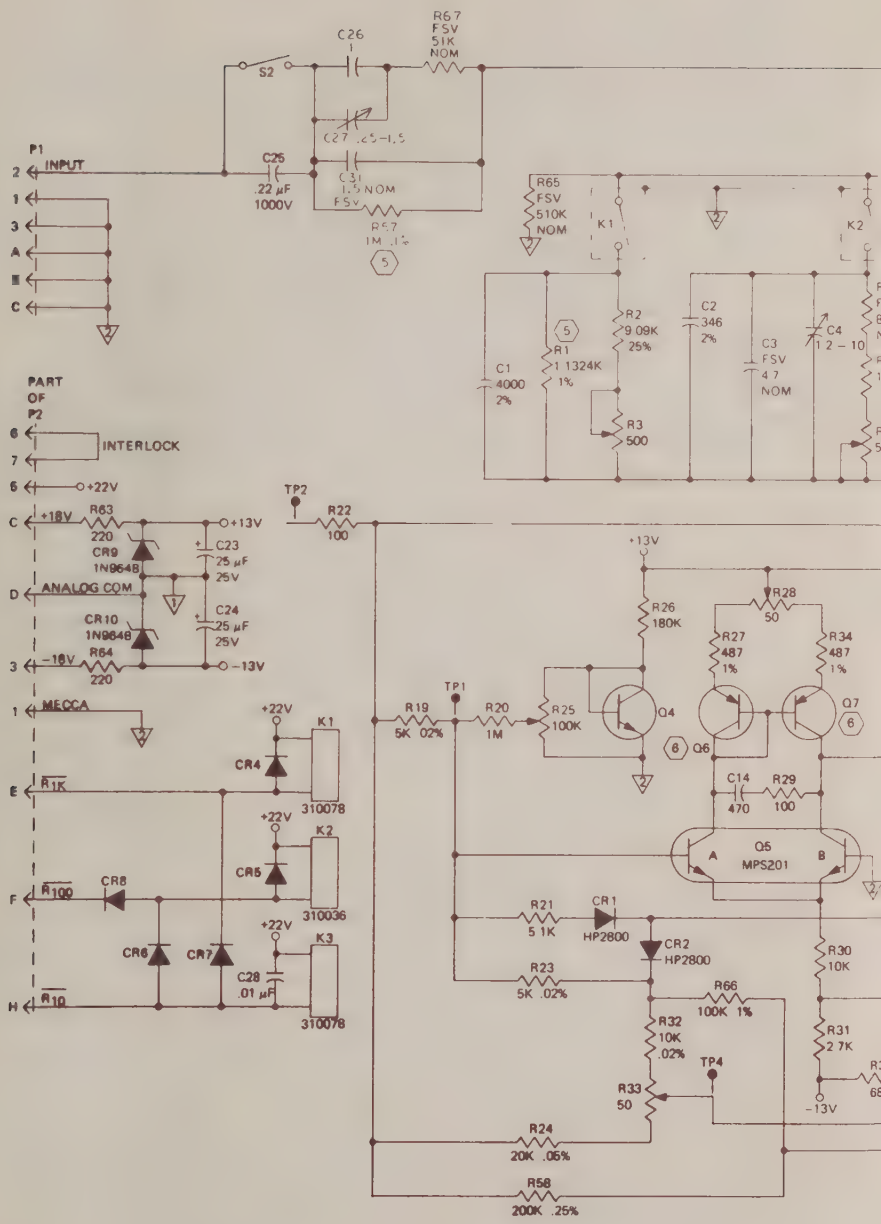
SCHEM 432014-C
ASSY 403640-C

Figure 6.9 - Schematic, AC Converter



403775-J

Figure 6.10 - Layout, RMS Converter


P1
INPUT
S2
C26
R67
FSV
51K
NOM
C27 .25-1.5
C25
.22 μF
1000V
C31
1.5 NOM
FSV
R67
1M 1%
R65
FSV
510K
NOM
K1
K2
R1
1 1324K
1%
R2
9.09K
25%
R3
500
C1
4000
2%
C2
346
2%
C3
FSV
4 7
NOM
C4
1 2 – 10
PART
OF
P2
INTERLOCK
+22V
+18V
R63
220
CR9
1N964B
C23
25 μF
25V
+13V
ANALOG COM
CR10
1N964B
C24
25 μF
25V
R64
220
–18V
–13V
MECCA
R1K
R100
R10
CR8
CR6
CR7
CR4
CR5
K1
K2
K3
310078
310036
C28
.01 μF
TP2
R22
100
TP1
R19
5K .02%
R20
1M
R25
100K
Q4
Q6
Q7
R26
180K
R27
487
1%
R28
50
R34
487
1%
C14
470
R29
100
Q5
MPS201
A
B
R21
5 1K
CR1
HP2800
CR2
HP2800
R23
5K .02%
R30
10K
R66
100K 1%
R32
10K
.02%
R33
50
TP4
R31
2 7K
R24
20K .05%
R58
200K .25%

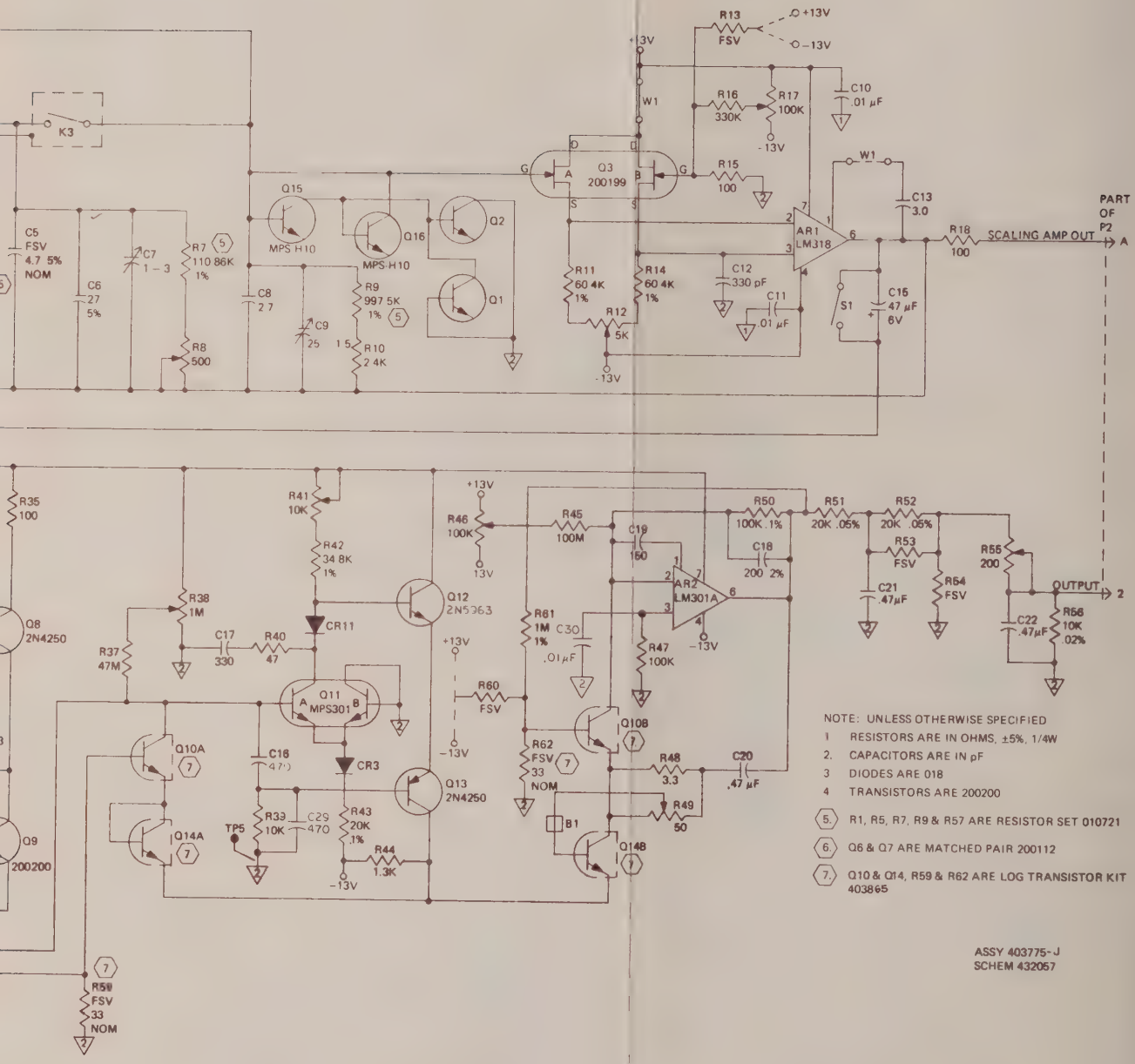
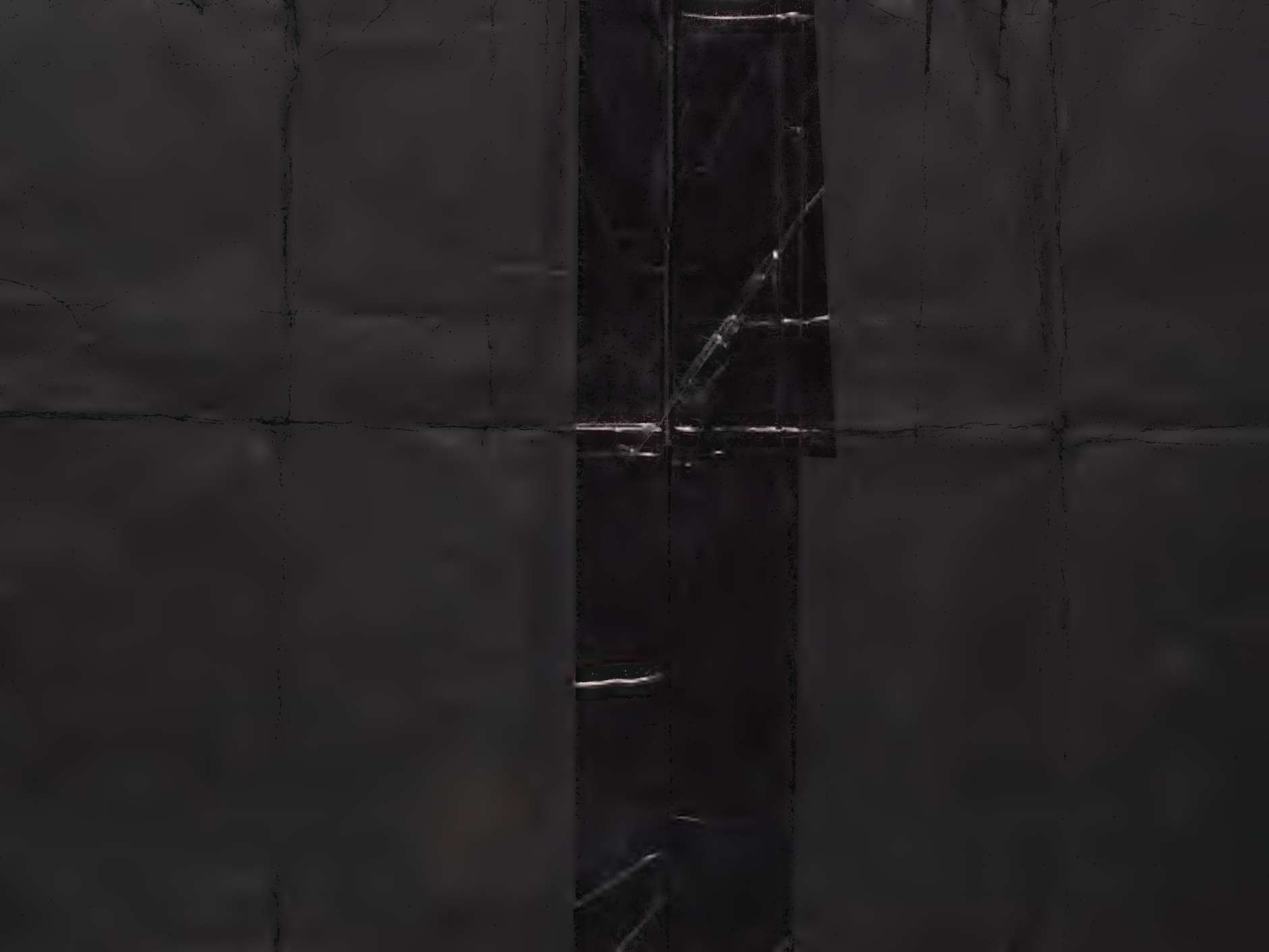
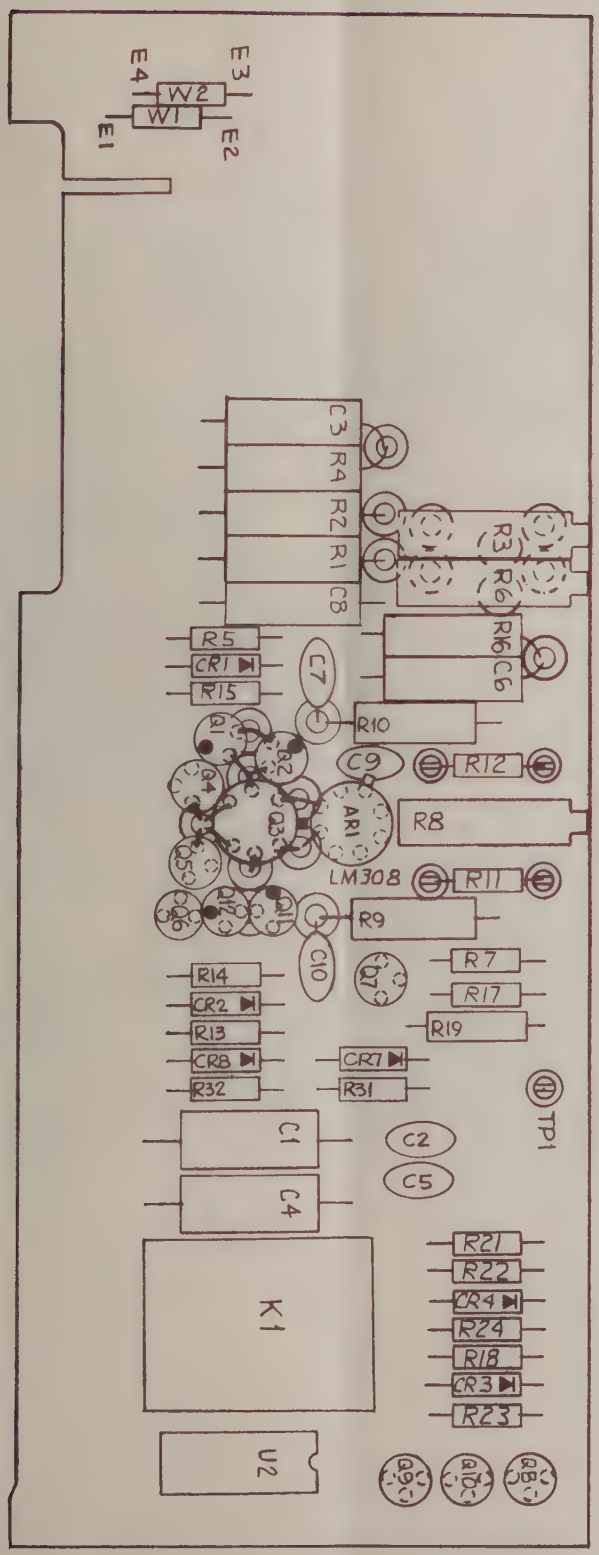


Figure 6.11 - Schematic, RMS Converter




E4
E3
W2
W1
E1
E2
C3
R4
R2
R1
C8
R3
R6
R6
C6
R5
CR1
R15
C7
R10
C9
R12
Q1
Q2
Q4
Q3
Q5
Q6
Q8
Q7
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q18
Q19
Q20
Q21
Q22
Q23
Q24
Q25
Q26
Q27
Q28
Q29
Q30
Q31
Q32
Q33
Q34
Q35
Q36
Q37
Q38
Q39
Q40
Q41
Q42
Q43
Q44
Q45
Q46
Q47
Q48

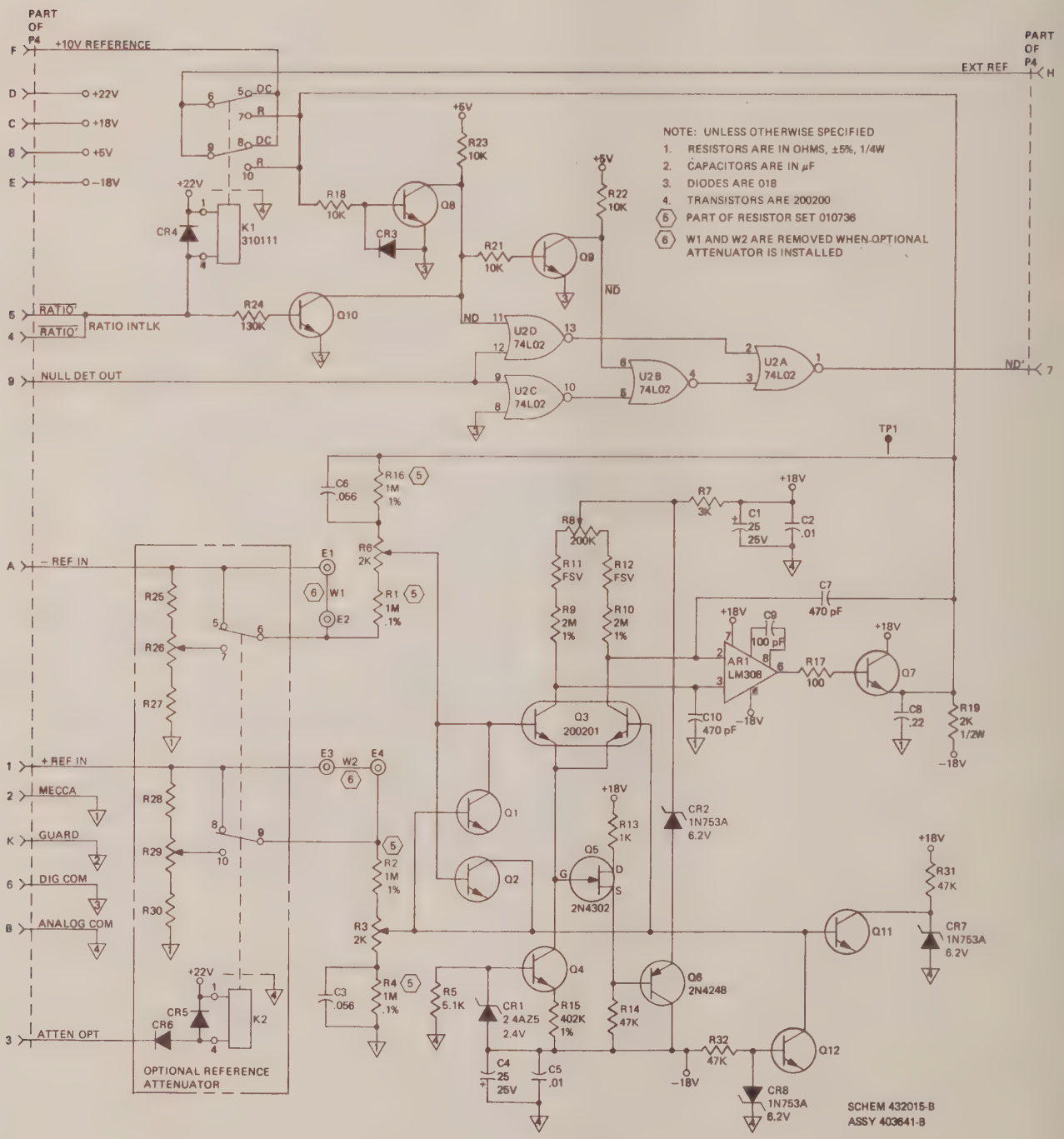


Figure 6.12 - Layout, Ratio Buffer

Figure 6.13 - Schematic, Ratio Buffer

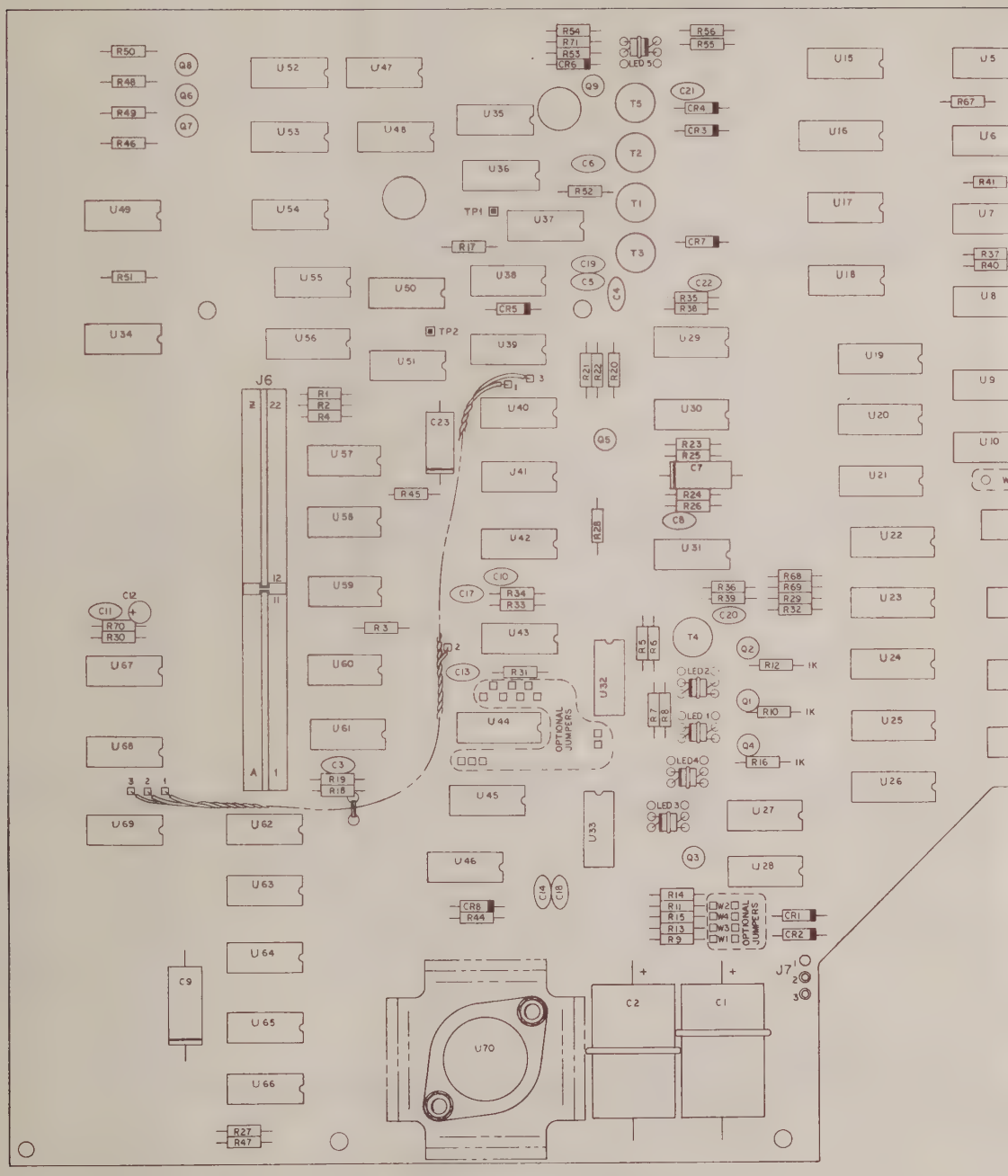
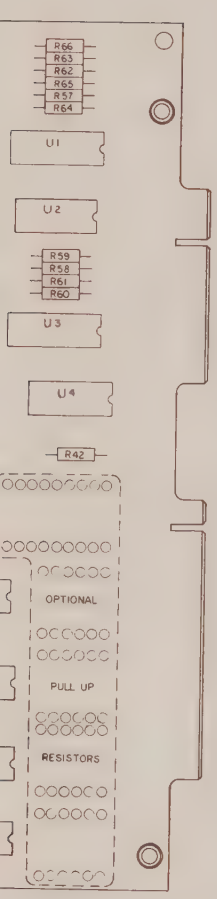
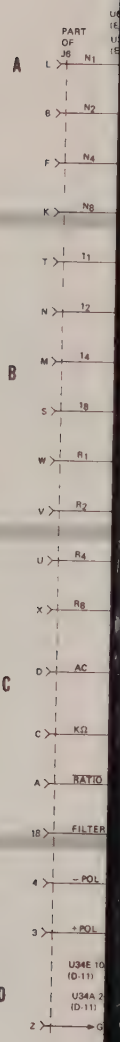


Figure 6.14 - Layout, Data Output & Programming


R66
R63
R62
R65
R57
R64
U1
U2
R59
R58
R61
R60
U3
U4
R42
OPTIONAL
PULL UP
RESISTORS


PART OF J6
A
B
C
D
E
L
N1
B
N2
F
N4
K
N8
T
T1
N
T2
M
T4
S
T8
W
R1
V
R2
U
R4
X
R8
D
AC
C
KΩ
A
RATIO
18
FILTER
4
– POL
3
+ POL
Z

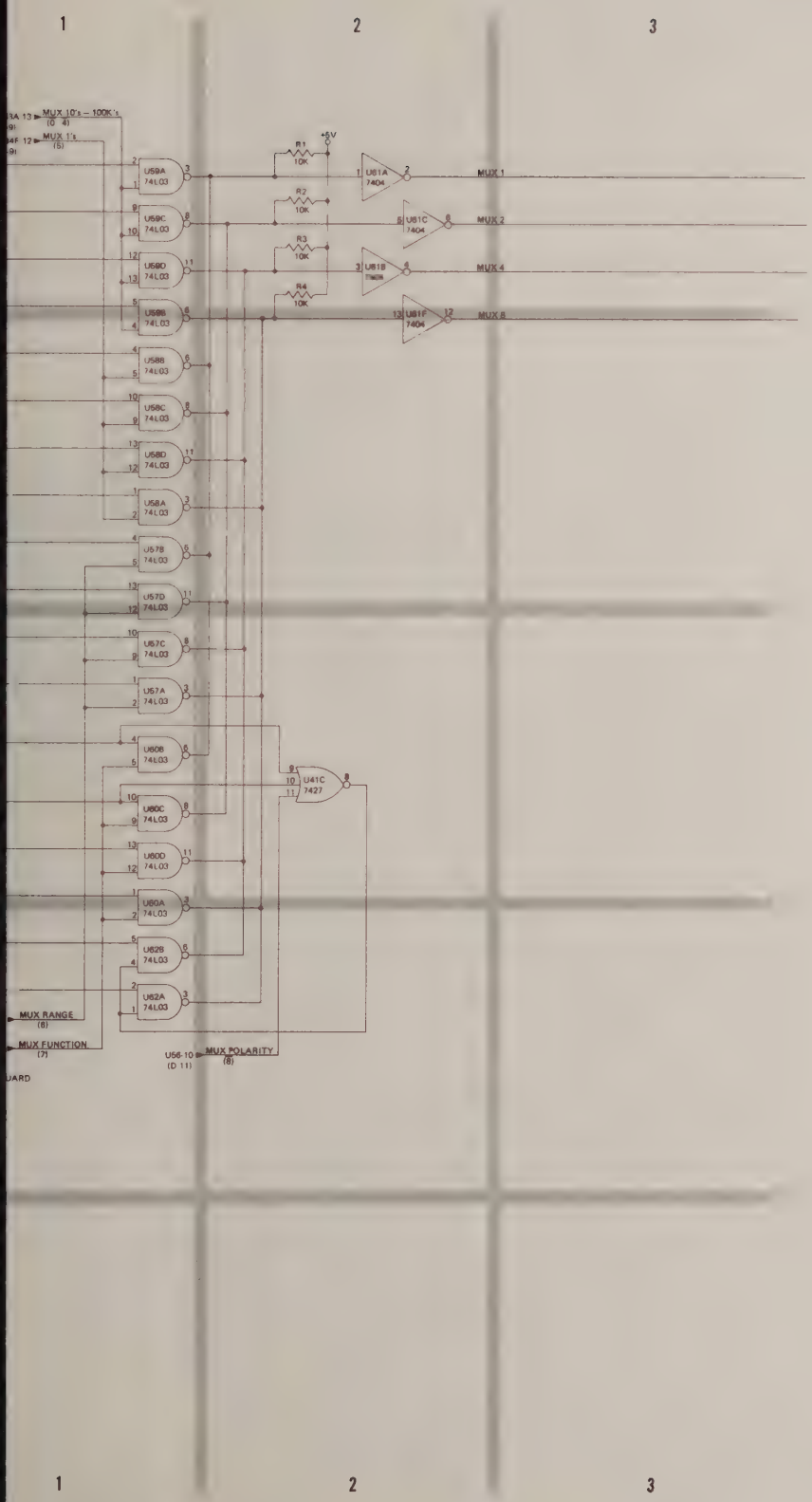
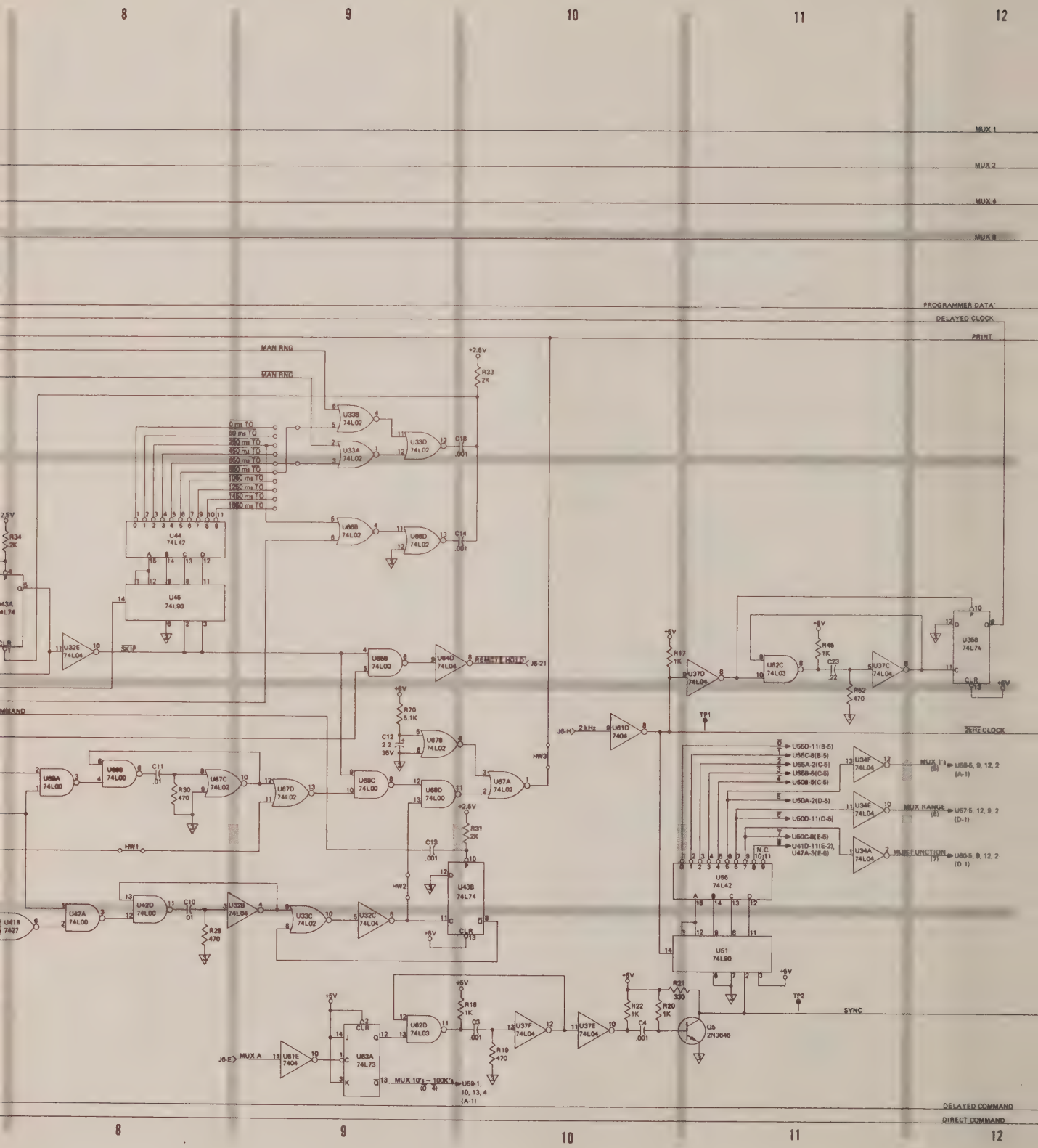
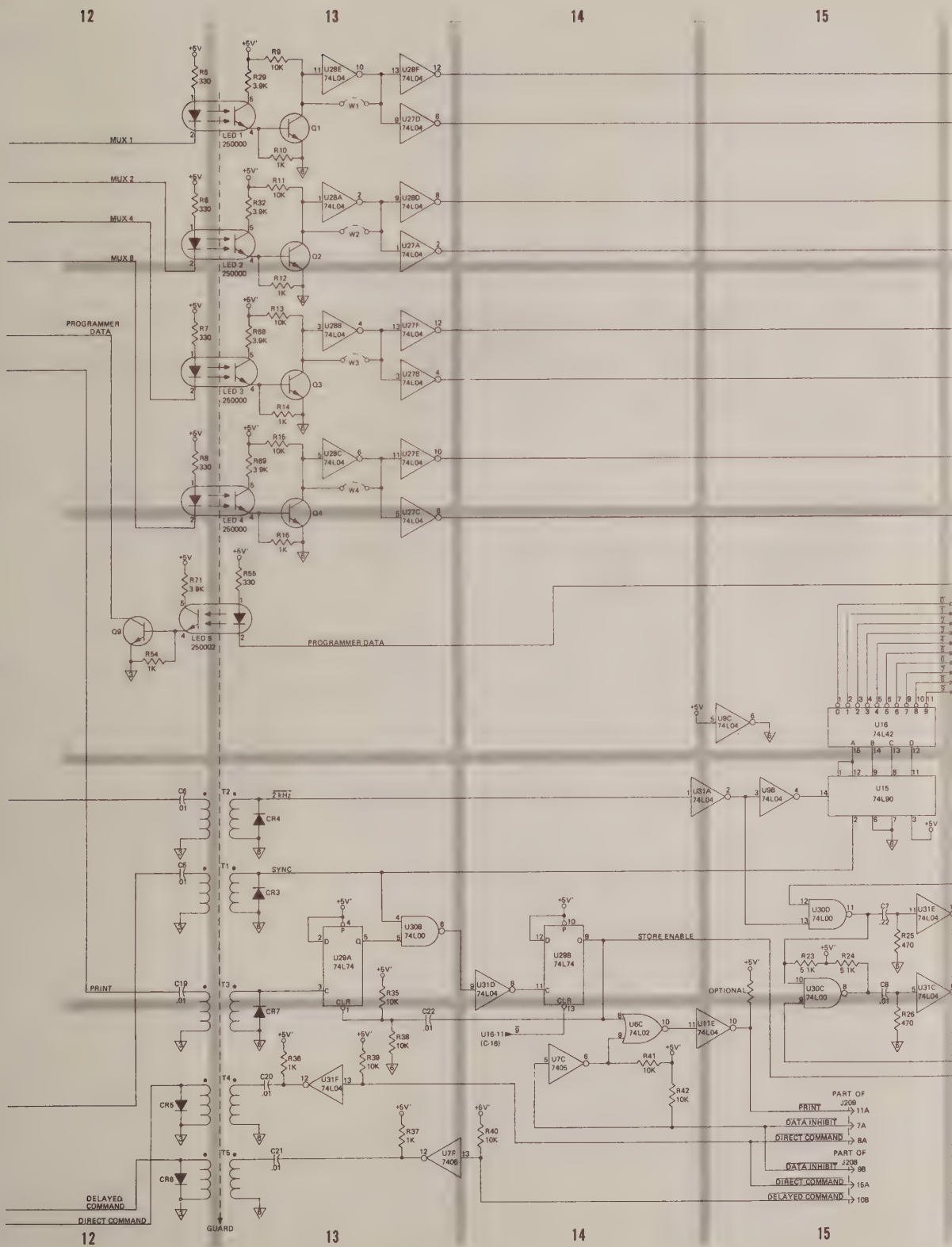
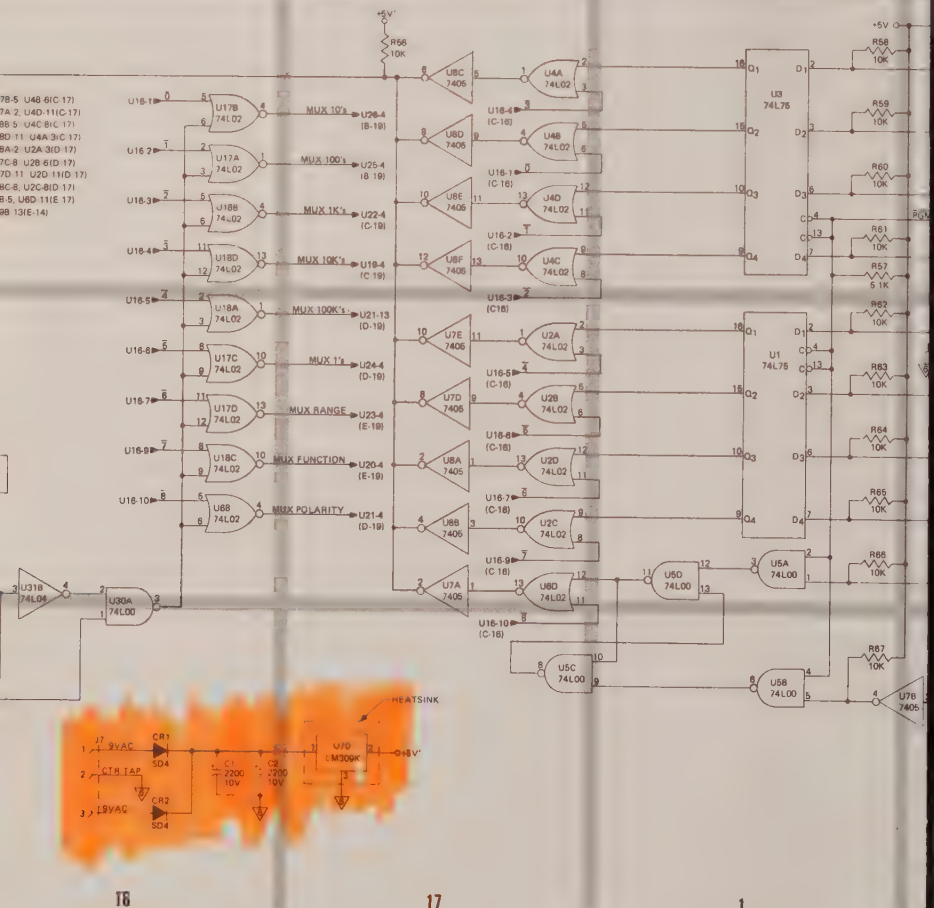
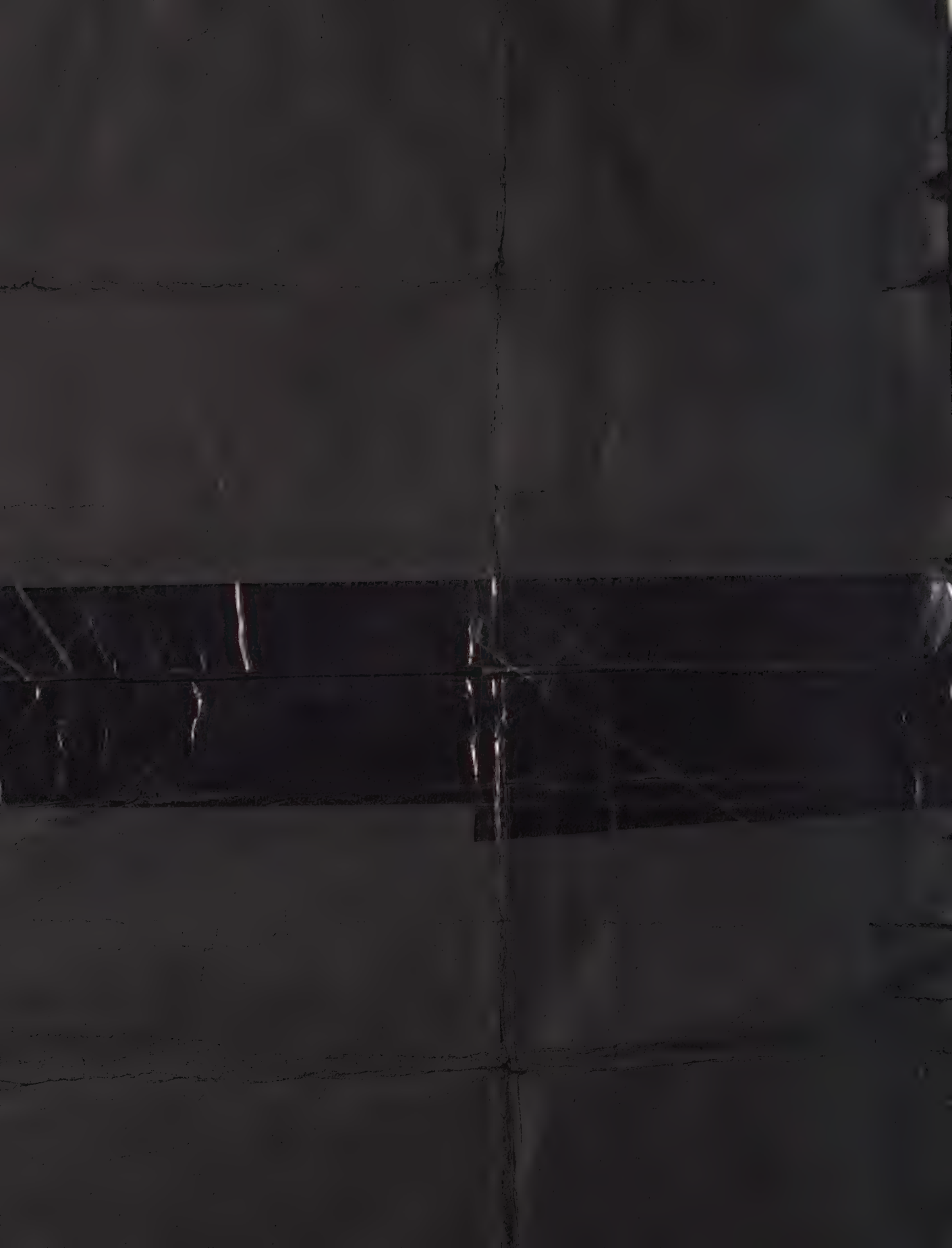


Figure 6.15 - Schematic, Data Output & Programming


8
9
10
11
12
MUX 1
MUX 2
MUX 4
MUX 8
PROGRAMMER DATA
DELAYED CLOCK
PRINT
MAN RNG
MAN RNG
+2.5V
R33 2K
0 ms TO
50 ms TO
250 ms TO
450 ms TO
650 ms TO
850 ms TO
1050 ms TO
1250 ms TO
1450 ms TO
1650 ms TO
U33B 74L02
U33A 74L02
U33D 74L02
C18 .001
U66B 74L02
U66D 74L02
C14 .001
U44 74L42
U45 74L90
U32E 74L04
SKIP
U65B 74L00
U64D 74L04
REMOTE HOLD
J6-21
+5V
R70 5.1K
C12 22 35V
U67B 74L02
HW3
U66A 74L00
U66B 74L00
C11 .01
U67C 74L02
R30 470
U67D 74L02
U66C 74L00
U66D 74L00
U67A 74L02
HW1
+2.5V
R31 2K
C13 .001
HW2
U43B 74L74
U42A 74L00
U42D 74L00
C10 .01
U32B 74L04
R28 470
U33C 74L02
U32C 74L04
+5V
U61B 7427
+8V
R17 1K
U37D 74L04
U62C 74L03
+8V
R46 1K
C23 .22
R52 470
U37C 74L04
U35B 74L74
CLR
+8V
J6-H
2 kHz
U61D 7404
TP1
2kHz CLOCK
U55D-11(B-5)
U55C-8(B-5)
U55A-2(C-5)
U55B-5(C-5)
U50B-5(C-5)
U34F 74L04
MUX 1's (B)
U58-5, 9, 12, 2 (A-1)
U50A-2(D-5)
U34E 74L04
MUX RANGE (8)
U57-5, 12, 9, 2 (D-1)
U50D-11(D-5)
U50C-8(E-5)
U41D-11(E-2), U47A-3(E-6)
N.C. 10,11
U34A 74L04
MUX FUNCTION (1)
U60-5, 9, 12, 2 (D 1)
U56 74L42
U51 74L90
+5V
R21 330
TP2
SYNC
+5V
R18 1K
C3 .001
U62D 74L03
U37F 74L04
U37E 74L04
+5V
R22 1K
R20 1K
C4 .001
Q5 2N3646
R19 470
+5V
J6-E
MUX A
U61E 7404
U63A 74L73
MUX 10's — 100K's (0 4)
U59-1, 10, 13, 4 (A-1)
DELAYED COMMAND
DIRECT COMMAND
8
9
10
11
12


12
13
14
15
MUX 1
MUX 2
MUX 4
MUX 8
PROGRAMMER DATA
LED 1 250000
LED 2 250000
LED 3 250000
LED 4 250000
LED 5 250002
PROGRAMMER DATA
SYNC
PRINT
STORE ENABLE
OPTIONAL
DELAYED COMMAND
DIRECT COMMAND
GUARD
PART OF J20B
PRINT
DATA INHIBIT
DIRECT COMMAND
DELAYED COMMAND


+5V
R56 10K
U8C 7405
U4A 74L02
U16-1 (C-16)
MUX 10's
U26-4 (B-19)
U17B 74L02
U8D 7405
U4B 74L02
U16-2 (C-16)
MUX 100's
U25-4 (B-19)
U17A 74L02
U8E 7405
U4D 74L02
U16-3 (C-16)
MUX 1K's
U22-4 (C-19)
U18B 74L02
U8F 7405
U4C 74L02
U16-4 (C-16)
MUX 10K's
U19-4 (C-19)
U18D 74L02
U16-5 (C18)
MUX 100K's
U21-13 (D-19)
U18A 74L02
U7E 7406
U2A 74L02
U16-6 (C-16)
MUX 1's
U24-4 (D-19)
U17C 74L02
U7D 7405
U2B 74L02
U16-7 (C-16)
MUX RANGE
U23-4 (E-19)
U17D 74L02
U8A 7405
U2D 74L02
U16-8 (C-16)
MUX FUNCTION
U20-4 (E-19)
U18C 74L02
U8B 7406
U2C 74L02
U16-9 (C-16)
MUX POLARITY
U21-4 (D-19)
U18B 74L02
U7A 7405
U6D 74L02
U16-10 (C-16)
U3 74L75
U1 74L75
R58 10K
R59 10K
R60 10K
R61 10K
R57 5.1K
R62 10K
R63 10K
R64 10K
R65 10K
R66 10K
R67 10K
U5A 74L00
U5B 74L00
U5C 74L00
U5D 74L00
U30A 74L00
U31B 74L04
U7B 7405
HEATSINK
J7
9VAC
CR1
SD4
CTR TAP
CR2
SD4
C1 2200 10V
C2 2200 10V
U7D LM309K
+5V



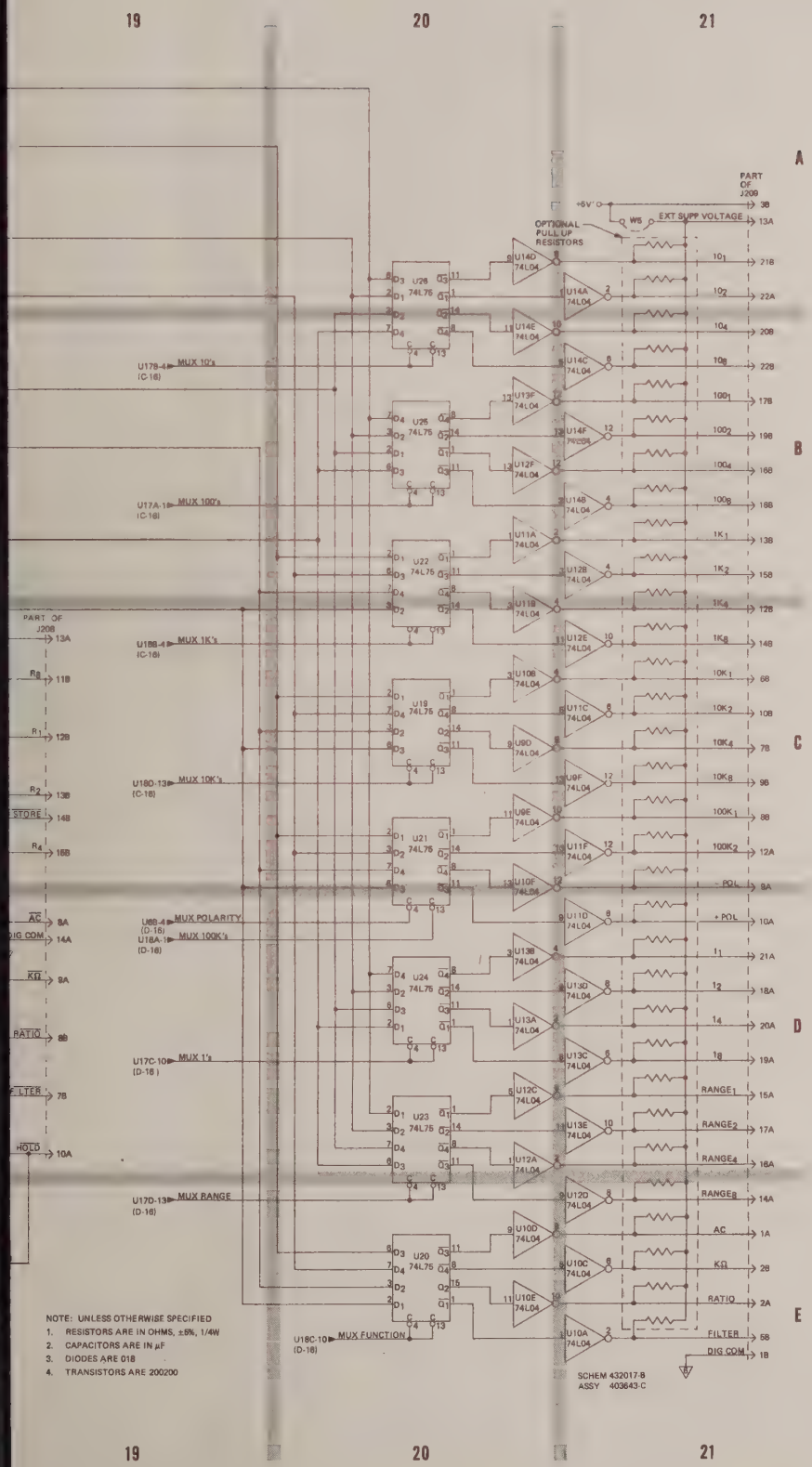


Figure 6.15 - Schematic, Data Output & Programming

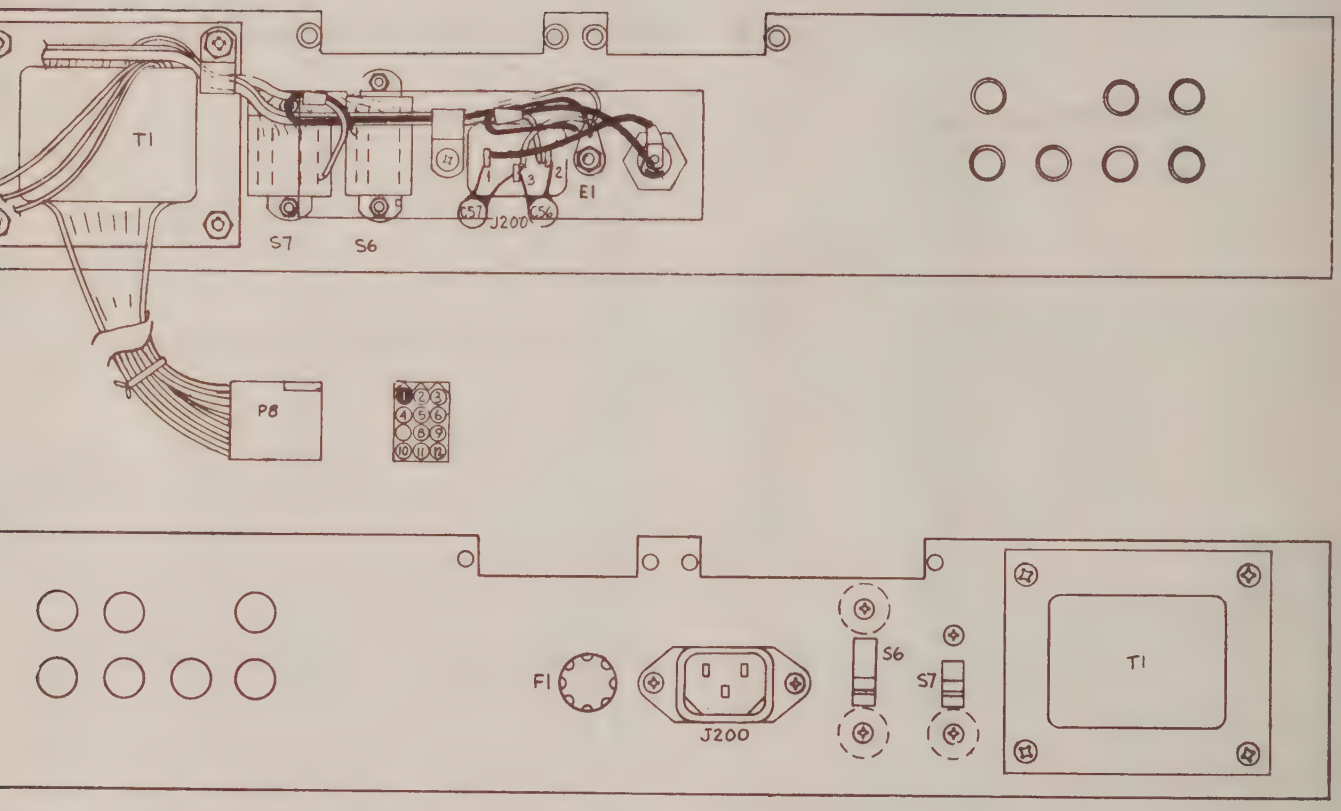


Figure 6.16 - Layout, Rear Panel

SECTION 7 PARTS LIST

7.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies:

	Page
Main Logic & Power Supply	7-3
Rear Panel	7-15
Display	7-17
Ohms Converter	7-18
AC Converter	7-20
RMS Converter	7-23
Ratio Buffer	7-27
Data Output & Programming	7-29

7.2 Manufacturers are identified by FSC numbers listed in table 7.2, "List of Suppliers". The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1, H4-2, and their supplements.

7.3 Certain parts having 21793 (Dana) listed in the "FSC" column are specially-selected semiconductors. For some of these, standard commercial parts will serve as satisfactory replacements. These Dana parts are identified in table 7.1 along with the commercial equivalent.

Table 7.1

Semiconductor Type:	Equivalent:
014 Transistor	Motorola 2N3501
018 Diode	Texas Instruments 1N4448
021 Transistor	MPS A42

Table 7.2 - List of Suppliers

FSC	NAME
00779	AMP, INC. HARRISBURG, PENNSYLVANIA
01121	ALLEN BRADLEY CO. MILWAUKEE, WISCONSIN
01295	TEXAS INSTRUMENTS, INC. (Components Group) DALLAS, TEXAS
02114	FERROXCUBE CORP. SAUGERTIES, NEW YORK
03888	PYROFILM CORPORATION WHIPPANY, NEW JERSEY
04713	MOTOROLA, INC. (Semiconductor Products Division) PHOENIX, ARIZONA
05397	UNION CARBIDE CORP. (Materials Systems Division) CLEVELAND, OHIO
06665	PRECISION MONOLITHICS SANTA CLARA, CALIFORNIA
07263	FAIRCHILD SEMICONDUCTOR (Division of Fairchild Camera & Instrument Corp.) MOUNTAIN VIEW, CALIFORNIA
07716	TRW ELECTRONIC COMPONENTS (IRC) BURLINGTON, IOWA
08257	NPC ELECTRONICS CANOGA PARK, CALIFORNIA
08806	GENERAL ELECTRIC (Miniature Light Division) CLEVELAND, OHIO
09023	CORNELL-DUBILIER ELECTRONICS (Division Federal Pacific Electric Co.) SANFORD, NORTH CAROLINA
11237	CTS KEENE, INC. PASO ROBLES, CALIFORNIA
13571	ELECTRONIC RESEARCH CO. OVERLAND PK., KANSAS

Table 7.2 - List of Suppliers continued

FSC	NAME
15636	ELEC-TROL, INC. SAUGUS, CALIFORNIA
17856	SILICONIX, INC. SANTA CLARA, CALIFORNIA
18612	VISHAY RESISTOR PRODUCTS (Division Vishay Intertechnology, Inc.) MALVERN, PENNSYLVANIA
21551	C-F ELECTRONICS, INC. VAN NUYS, CALIFORNIA
21793	DANA LABORATORIES, INC. IRVINE, CALIFORNIA
22045	JORDAN ELECTRIC CO. VAN NUYS, CALIFORNIA
22753	UID ELECTRONICS CORP. HOLLYWOOD, FLORIDA
23095	AZTEC ELECTRONICS, INC. ANAHEIM, CALIFORNIA
24796	PARELCO, INC. SAN JUAN CAPISTRANO, CALIFORNIA
26625	MIAL USA, INC. NUTLEY, NEW JERSEY
27014	NATIONAL SEMI-CONDUCTOR CORP. SANTA CLARA, CALIFORNIA
27264	MOLEX PRODUCTS CO. DOWNERS GROVE, ILLINOIS
27556	IMB ELECTRONIC PRODUCTS, INC. SANTA FE SPRINGS, CALIFORNIA
34553	AMPEREX/MEPCO-ELECTRA HAUPPAUGE, NEW YORK
50434	HEWLETT-PACKARD CO. (HP Associates) PALO ALTO, CALIFORNIA
56289	SPRAGUE ELECTRIC CO. (Pacific Division) LOS ANGELES, CALIFORNIA
71471	AEROVOX CORP. (Cinema Plant) MONCKS CORNER, SOUTH CAROLINA
71590	CENTRALAB ELECTRONICS (Division of Globe-Union, Inc.) MILWAUKEE, WISCONSIN
71785	TRW ELECTRONIC COMPONENTS (Cinch Division) ELK GROVE VILLAGE, ILLINOIS
72136	ELECTRO MOTIVE MFG. CO., INC. WILLIMANTIC, CONNECTICUT
73138	BECKMAN INSTRUMENTS, INC. (Helipot Division) FULLERTON, CALIFORNIA
73445	AMPEREX ELECTRONIC CORP. HICKSVILLE, LONG ISLAND, NEW YORK
74970	E. F. JOHNSON CO. WASECA, MINNESOTA
75915	LITTELFUSE, INC. DES PLAINES, ILLINOIS
79727	C-W INDUSTRIES WARMINSTER, PENNSYLVANIA
80131	ELECTRONIC INDUSTRIES ASSOC. WASHINGTON, D.C.
81349	MILITARY SPECIFICATION
82389	SWITCHCRAFT, INC. CHICAGO, ILLINOIS
87730	UNITED MINERAL & CHEMICAL CORP. NEW YORK CITY, NEW YORK
89110	AMP, INC. (Capitron Division) ELIZABETHTOWN, PENNSYLVANIA
99800	AMERICAN PRECISION INDUSTRIES, INC. (Delevan Division) EAST AURORA, NEW YORK

403642 – Assy., PCB, MAIN LOGIC

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	101182	CAP	CERAM	47 PFD		10%	71471	TCD-DI-2(N750)
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C3	130144	CAP	MICA	270 PFD	100 V	5%	72136	DM10271J0100WV4
C4	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C7	110066	CAP	ELECT	16 MFD	200 V		73445	C436AR/L16
C8	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C9	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C10	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C11	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C12	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C13	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C14	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C15	100016	CAP	CERAM	27 PFD		10%	71590	DD270
C16	100016	CAP	CERAM	27 PFD		10%	71590	DD270
C17	100016	CAP	CERAM	27 PFD		10%	71590	DD270
C18	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C19	101641	CAP	CERAM	470 PFD		10%	71471	SCD1X5F
C21	120268	CAP	POLY	.56 MFD	100 V	5%	71785	863UW
C22	101641	CAP	CERAM	470 PFD		10%	71471	SCD1X5F
C24	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C26	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C27	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C28	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C29	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C30	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C31	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C32	100051	CAP	CERAM	3 PFD	500 V		71471	TCD-B1-0
C33	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C34	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	TG-S20
C35 •	120001	CAP	MYLAR	.0033 MFD	100 V	10%	09023	WMF1D33
C36	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C37	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C38	120314	CAP	POLY	.02 MFD	100 V	5%	08257	KSC Series
C39	120271	CAP	POLY	.5 MFD	50 V	5%	27556	PV2A504J
C40	120004	CAP	POLY	.001 MFD	500 V	5%	08257	KSO Series
C41	120004	CAP	POLY	.001 MFD	500 V	5%	08257	KSO Series
C42	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
C43	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C44	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C45	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C46	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C47	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C48	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C49	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C50	110128	CAP	ELECT	6000 MFD	10 V	–10%+75%	56289	36D602G010AA2A
C51	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C52	110067	CAP	ELECT	2000 MFD	35 V		87730	2000DXW35
C53	110067	CAP	ELECT	2000 MFD	35 V		87730	2000DXW35
C54	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C55	110036	CAP	ELECT	22 MFD	63 V		34553	ET220X063A5
C56	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F
C57	101175	CAP	CERAM	220 PFD	100 V	10%	71471	SCD1X5F*
C58	100043	CAP	CERAM	.003 PFD	1000 V	10%	71590	DD302
C59	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C60	110121	CAP	ELECT	2200 MFD	10 V		34553	ET222X010A03
CR1	211083	DIODE	SILICO			018	21793	211083
CR2	221177	DIODE	SILICO	ZENER		1/4M.2.4AZ5	04713	1/4M.2.4AZ5
CR3	211083	DIODE	SILICO			018	21793	211083
CR4	211083	DIODE	SILICO			018	21793	211083
CR5	211083	DIODE	SILICO			018	21793	211083
CR6	211083	DIODE	SILICO			018	21793	211083
CR7	221177	DIODE	SILICO	ZENER		1/4M.2.4AZ5	04713	1/4M.2.4AZ5
CR8	211083	DIODE	SILICO			018	21793	211083
CR9	211083	DIODE	SILICO			018	21793	211083
CR10	211083	DIODE	SILICO			018	21793	211083
CR11	211083	DIODE	SILICO			018	21793	211083
CR12	403294	DIODE	ZENER KIT			6.2 V	21793	403294
CR13	211083	DIODE	SILICO			018	21793	211083
CR14	211083	DIODE	SILICO			018	21793	211083
CR15	211083	DIODE	SILICO			018	21793	211083
CR16	211083	DIODE	SILICO			018	21793	211083
CR17	211083	DIODE	SILICO			018	21793	211083
CR18	211083	DIODE	SILICO			018	21793	211083
CR19	220026	DIODE		ZENER			81349	1N963B
CR20	220040	DIODE		ZENER			81349	1N753A
CR21	211083	DIODE	SILICO			018	21793	211083
CR22	220026	DIODE		ZENER			81349	1N963B
CR23	220026	DIODE		ZENER			81349	1N963B
CR24	211083	DIODE	SILICO			018	21793	211083
CR25	211083	DIODE	SILICO			018	21793	211083
CR26	220007	DIODE	SILICO	ZENER			81349	1N751A

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR27	220007	DIODE	SILICO	ZENER			81349	1N751A
CR28	211083	DIODE	SILICO		018		21793	211083
CR29	211083	DIODE	SILICO		018		21793	211083
CR30	211083	DIODE	SILICO		018		21793	211083
CR31	211083	DIODE	SILICO		018		21793	211083
CR32	211083	DIODE	SILICO		018		21793	211083
CR33	210004	DIODE	SILICO		1N4004		81349	1N4004
CR34	211083	DIODE	SILICO		018		21793	211083
CR35	210004	DIODE	SILICO		1N4004		81349	1N4004
CR36	210004	DIODE	SILICO		1N4004		81349	1N4004
CR37	210004	DIODE	SILICO		1N4004		81349	1N4004
CR38	210004	DIODE	SILICO		1N4004		81349	1N4004
CR39	210004	DIODE	SILICO		1N4004		81349	1N4004
CR40	210004	DIODE	SILICO		1N4004		81349	1N4004
CR41	210004	DIODE	SILICO		1N4004		81349	1N4004
CR42	210004	DIODE	SILICO		1N4004		81349	1N4004
CR43	210004	DIODE	SILICO		1N4004		81349	1N4004
CR44	220026	DIODE		ZENER			81349	1N963B
CR45	221255	DIODE	SILICO	ZENER			81349	1N969B
CR46	220026	DIODE		ZENER			81349	1N963B
CR47	220060	DIODE		ZENER	24 V	5%	81349	1N970B
CR48	211083	DIODE	SILICO		018		21793	211083
CR49	211083	DIODE	SILICO		018		21793	211083
CR50	220026	DIODE		ZENER			81349	1N963B
CR51	211083	DIODE	SILICO		018		21793	211083
CR52	211083	DIODE	SILICO		018		21793	211083
CR53	211083	DIODE	SILICO		018		21793	211083
DS1	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS2	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS3	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS4	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS5	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS6	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS7	920342	LAMP	NEON		NE 2H		08806	C2A-M
DS8	920342	LAMP	NEON		NE 2H		08806	C2A-M
E59	610402	PIN	FORMED		60824-1		89110	60824-1
E60	610402	PIN	FORMED		60824-1		89110	60824-1
E61	610402	PIN	FORMED		60824-1		89110	60824-1
E62	610402	PIN	FORMED		60824-1		89110	60824-1
J1	600689	CONN	3 PIN		4-583486-8		89110	4-583486-8
J2	600690	CONN	7 PIN		4-583486-4		89110	4-583486-4

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
J3	600632	CONN 11 PIN 4-583486-0	89110	4-583486-0
J4	600632	CONN 11 PIN 4-583486-0	89110	4-583486-0
J5	600658	CONN 22 PIN 2-583486-9	89110	2-583486-9
J8	600688	RECEPTACLE A-1840-12	27264	A-1840-12
J9	600694	CONN 15 PIN 3-583486-5	89110	3-583486-5
K1	310112	RELAY 28 V	24796	R10-E2315-2
K2	310111	RELAY 28 V	24796	R10-E2314-2
K3	310111	RELAY 28 V	24796	R10-E2314-2
K4	310111	RELAY 28 V	24796	R10-E2314-2
K7	310036	RELAY REED R2096-3	15636	R2096-3
L1	310062	CHOKE 22 μH 1537-44	99800	1537-44
Q1	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q2	200184	TRANS PNP MPS-A55	04713	MPS-A55
Q3	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q4	200184	TRANS PNP MPS-A55	04713	MPS-A55
Q5	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q6	200184	TRANS PNP MPS-A55	04713	MPS-A55
Q7	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q8	200184	TRANS PNP MPS-A55	04713	MPS-A55
Q9	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q10	200184	TRANS PNP MPS-A55	04713	MPS-A55
Q11	200087	TRANS SILICO 021	21793	200087
Q12	200087	TRANS SILICO 021	21793	200087
Q13	200087	TRANS SILICO 021	21793	200087
Q14	200087	TRANS SILICO 021	21793	200087
Q15	200087	TRANS SILICO 021	21793	200087
Q16	200087	TRANS SILICO 021	21793	200087
Q17	200087	TRANS SILICO 021	21793	200087
Q18	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q19	200200	TRANS NPN 200200	21793	200200
Q20	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q21	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q22	200200	TRANS NPN 200200	21793	200200
Q23	200200	TRANS NPN 200200	21793	200200
Q24	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q25	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q26	200200	TRANS NPN 200200	21793	200200
Q27	200217	TRANS SELECTED 200217	21793	200217
Q28	200088	TRANS SILICO PNP 2N4248	80131	2N4248

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
Q29	200200	TRANS		NPN	200200		21793	200200
Q30	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q31	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q32	200217	TRANS	SELECTED		200217		21793	200217
Q33	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q34	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q35	200217	TRANS	SELECTED		200217		21793	200217
Q36	200160	TRANS	FET		E-304		17856	E-304
Q37	200160	TRANS	FET		E-304		17856	E-304
Q38	200161	TRANS	FET		E-415		17856	E-415
Q39	200200	TRANS		NPN	200200		21793	200200
Q40	200200	TRANS		NPN	200200		21793	200200
Q41	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q42	200200	TRANS		NPN	200200		21793	200200
Q43	200222	TRANS			200222		21793	200222
Q44	200068	TRANS			2N4250		80131	2N4250
Q45	200200	TRANS		NPN	200200		21793	200200
Q46	200201	TRANS	DUAL	NPN	200201		21793	200201
Q47	200200	TRANS		NPN	200200		21793	200200
Q48	200199	TRANS	DUAL		200199		21793	200199
Q49	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q50	200200	TRANS		NPN	200200		21793	200200
Q51	200166	TRANS		NPN	MPS-U05		04713	MPS-U05
Q52	200200	TRANS		NPN	200200		21793	200200
Q53	200200	TRANS		NPN	200200		21793	200200
Q54	200035	TRANS	SILICO	NPN	014		21793	200035
Q55	200167	TRANS		PNP	MPS-U55		04713	MPS-U55
Q56	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q57	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q58	200200	TRANS		NPN	200200		21793	200200
R1	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R2	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R3	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R4	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R5	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R6	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R7	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R8	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R9	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R11	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R12	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
R13	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R15	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R16	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R17	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R19	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R20	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R21	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R22	000164	RES	CARBON	160 K	5% 1/4W	81349	RC07GF164J
R23	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R24	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R25	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R26	000431	RES	CARBON	430 OHM	5% 1/4W	81349	RC07GF431J
R27	000202	RES	CARBON	2 K	5% 1/4W	81349	RC07GF202J
R28	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R29	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R30	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R31	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R32	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R33	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R34	000511	RES	CARBON	510 OHM	5% 1/4W	81349	RC07GF511J
R35	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R36	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R37	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R38	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R39	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R40	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R41	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R42	000512	RES	CARBON	5.1 K	5% 1/4W	81349	RC07GF512J
R43	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R44	000363	RES	CARBON	36 K	5% 1/4W	81349	RC07GF363J
R45	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R46	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R47	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R48	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R49	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R50	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R51	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R52	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R53	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R54	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R55	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J
R56	000103	RES	CARBON	10 K	5% 1/4W	81349	RC07GF103J

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R57	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R58	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R59	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R60	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R61	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R62	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R63	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R64	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R65	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R66	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R67	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R68	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R69	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R70	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R71	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R72	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R73	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R74	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R75	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R76	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R77	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R78	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R79	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R80	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R81	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R82	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R83	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R84	000431	RES	CARBON	430 OHM		5% 1/4W	81349	RC07GF431J
R85	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R86	000183	RES	CARBON	18 K		5% 1/4W	81349	RC07GF183J
R87	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R88	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R89	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R90	010791	RES	METAL	100 K	Matched Set	.1%	21793	010791
R91	010791	RES	METAL	100 K	Matched Set	.1%	21793	010791
R92	000332	RES	CARBON	3.3 K		5% 1/4W	81349	RC07GF332J
R93	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R94	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R95	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R96	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R97	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R98	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R99	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R100	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R101	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R102	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R103	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R104	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R105	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R106	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R107	010621	RES	METAL	49.9 K	T-0	1% 1/10W	81349	RN55C4992F
R108	040193	POT	CERMET	100 OHM		20%	11237	360T101B
R109	600245	JUMPER			L-2007-1LP			L-2007-1LP
R110	600245	JUMPER			L-2007-1LP			L-2007-1LP
R111	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R112	010678	RES	METAL	60.4 K		1% 1/10W	81349	RN55C
R113	010678	RES	METAL	60.4 K		1% 1/10W	81349	RN55C
R114	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R115	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R116	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R117	040251	POT	CERMET	250 K		20% .5W	73138	72PX250K
R118	000155	RES	CARBON	1.5 M		5% 1/4W	81349	RC07GF155J
R119	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R120	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J
R121	000825	RES	CARBON	8.2 M		5% 1/4W	81349	RC07GF825J
R122	010027	RES	METAL	499 OHM	T-0	1% 1/8W	81349	RN60D4990F
R123	000752	RES	CARBON	7.5 K		5% 1/4W	81349	RC07GF752J
R124	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R125	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R126	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R127	000183	RES	CARBON	18 K		5% 1/4W	81349	RC07GF183J
R128	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R129	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R130	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R131	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R132	000122	RES	CARBON	1.2 K		5% 1/4W	81349	RC07GF122J
R133	000391	RES	CARBON	390 OHM		5% 1/4W	81349	RC07GF391J
R134	403294	RES	ASSY	500 OHM		1%	21793	403294
R135	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R136	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737
R137	403294	RES	ASSY	6.6 K		.1%	21793	403294
R138	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J
R139	040248	POT	CERMET	20 K		20% .5W	73138	89PR20K
R140	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737

403642 -- Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R141	020552	RES	WW	3.9976 K		.05% 1/4W	22045	J-120
R142	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R143	010896	RES	METAL	5 K	MATCHED PR.	.02%	21793	010896
R144	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737
R145	000515	RES	CARBON	5.1 M		5% 1/4W	81349	RC07GF515J
R146	040188	POT	CERMET	100 K		20%	11237	360T104B
R147	001737	RES	CARBON	FSV	001737	5% 1/4W	21793	001737
R148	010896	RES	METAL	5 K	MATCHED PR.	.02%	21793	010896
R149	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R150	000106	RES	CARBON	10 M		5% 1/4W	81349	RC07GF106J
R151	040188	POT	CERMET	100 K		20%	11237	360T104B
R152	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R153	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R154	030015	RES	WW	100 K		1% 10 W	21551	M-100
R155	010857	RES	METAL	4.9875 M	SET	.1%	21793	010857
R157	000245	RES	CARBON	2.4 M		5% 1/4W	81349	RC07GF245J
R158	040264	POT	CERMET	25 K		20% .5W	73138	72XW25K
R159	010857	RES	METAL	4.485 M	SET	.1%	21793	010857
R161	040262	POT	CERMET	5 K		20% .5W	73138	72XW5K
R162	010857	RES	METAL	447.25 K	SET	.1%	21793	010857
R163	040211	POT	CERMET	500 OHM		20%	11237	360S Series
R164	000245	RES	CARBON	2.4 M		5% 1/4W	81349	RC07GF245J
R165	010857	RES	METAL	49.75 K	SET	.1%	21793	010857
R166	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R167	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R168	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R169	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R170	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R171	010096	RES	METAL	2.21 M	T-2	1% 1W	81349	RN75C2214F
R172	040260	POT	CERMET	1 K		20%	73138	72XW1K
R173	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R174	040188	POT	CERMET	100 K		20%	11237	360T104B
R175	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R176	000331	RES	CARBON	330 OHM		5% 1/4W	81349	RC07GF331J
R177	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R178	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R179	010701	RES	METAL	3.3 M	T-0	1% 1/4W	81349	RN65D
R180	600245	JUMPER			L-2007-1LP			L-2007-1LP
R181	040235	POT	CERMET	100 K	89PR100K		73138	89PR100K
R182	600245	JUMPER			L-2007-1LP			L-2007-1LP

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R183	010701	RES	METAL	3.3 M	T-0	1% 1/4W	81349	RN65D
R184	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R185	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R186	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R187	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R188	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R189	000913	RES	CARBON	91 K		5% 1/4W	81349	RC07GF913J
R190	000913	RES	CARBON	91 K		5% 1/4W	81349	RC07GF913J
R191	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R192	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R193	000333	RES	CARBON	33 K		5% 1/4W	81349	RC07GF333J
R194	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R195	000301	RES	CARBON	300 OHM		5% 1/4W	81349	RC07GF301J
R196	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R197	020652	RES	WW	7.996 K	SET	.05%	21793	020652
R198	000824	RES	CARBON	820 K		5% 1/4W	81349	RC07GF824J
R199	040196	POT	CERMET	1 K		20%	11237	360T102B
R200	001811	RES	CARBON	3.9 OHM		5% 1/4W	01121	See Descrpt.
R201	000184	RES	CARBON	180 K		5% 1/4W	81349	RC07GF184J
R202	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R203	020652	RES	WW	1.796 K	SET	.05%	21793	020652
R204	000513	RES	CARBON	51 K		5% 1/4W	81349	RC07GF513J
R205	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R206	040188	POT	CERMET	100 K		20%	11237	360T104B
R207	020652	RES	WW	200.4 OHM	SET	.05%	21793	020652
R208	001796	RES	CARBON	2.7 OHM		5% 1/4W	01121	See Descrpt.
R209	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R210	000123	RES	CARBON	12 K		5% 1/4W	81349	RC07GF123J
R211	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R212	000152	RES	CARBON	1.5 K		5% 1/4W	81349	RC07GF152J
R213	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R214	001796	RES	CARBON	2.7 OHM		5% 1/4W	01121	See Descrpt.
R215	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R216	000123	RES	CARBON	12 K		5% 1/4W	81349	RC07GF123J
R217	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R218	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R219	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R220	000511	RES	CARBON	510 OHM		5% 1/4W	81349	RC07GF511J
R221	000205	RES	CARBON	2 M		5% 1/4W	81349	RC07GF205J

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
R225	000105	RES	CARBON	1 M	5% 1/4W	81349	RC07GF105J
R226	000106	RES	CARBON	10 M	5% 1/4W	81349	RC07GF106J
R227	000244	RES	CARBON	240 K	5% 1/4W	81349	RC07GF244J
R228	000244	RES	CARBON	240 K	5% 1/4W	81349	RC07GF244J
R229	000102	RES	CARBON	1 K	5% 1/4W	81349	RC07GF102J
R230	010857	RES	METAL	Range Divider		21793	010857
R231	010857	RES	METAL	Range Divider		21793	010857
S1	600630	SWITCH	ROTARY			11237	
S2	600631	SWITCH	ROTARY			11237	
S3	600731	SWITCH	SLIDE	G-126		79727	G-126
S4	600731	SWITCH	SLIDE	G-126		79727	G-126
TP6	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP7	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP8	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP9	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP10	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP11	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP14	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP15	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP20	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
TP24	600786	POST	TERMINAL	1-87022-0		00779	1-87022-0
U1	230132	INTEGRATED CIRCUIT		SN7447N		01295	SN7447N
U2	230065	INTEGRATED CIRCUIT		SN7475N		01295	SN7475N
U3	230037	INTEGRATED CIRCUIT		SN7490N		01295	SN7490N
U4	230132	INTEGRATED CIRCUIT		SN7447N		01295	SN7447N
U5	230143	INTEGRATED CIRCUIT		SN74145		01295	SN74145
U6	230120	INTEGRATED CIRCUIT		3814		07263	3814
U7	230064	INTEGRATED CIRCUIT		SN7404N		01295	SN7404N
U8	230141	INTEGRATED CIRCUIT		SN74L74N		01295	SN74L74N
U9	230137	INTEGRATED CIRCUIT		SN74L03N		01295	SN74L03N
U10	230064	INTEGRATED CIRCUIT		SN7404N		01295	SN7404N
U11	230028	INTEGRATED CIRCUIT		SN7400N		01295	SN7400N
U12	230072	INTEGRATED CIRCUIT		SN7474N		01295	SN7474N
U13	230064	INTEGRATED CIRCUIT		SN7404N		01295	SN7404N
U14	230030	INTEGRATED CIRCUIT		SN7402N		01295	SN7402N
U15	230030	INTEGRATED CIRCUIT		SN7402N		01295	SN7402N
U16	230030	INTEGRATED CIRCUIT		SN7402N		01295	SN7402N
U17	230135	INTEGRATED CIRCUIT		SN7427N		01295	SN7427N
U18	230028	INTEGRATED CIRCUIT		SN7400N		01295	SN7400N
U19	230028	INTEGRATED CIRCUIT		SN7400N		01295	SN7400N
U20	230031	INTEGRATED CIRCUIT		SN7410N		01295	SN7410N

403642 – Assy., PCB, MAIN LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION		FSC	MANU P/N
U21	230073	INTEGRATED CIRCUIT	SN7405N	01295	SN7405N
U22	230064	INTEGRATED CIRCUIT	SN7404N	01295	SN7404N
U23	230030	INTEGRATED CIRCUIT	SN7402N	01295	SN7402N
U24	230067	INTEGRATED CIRCUIT	SN74192N	01295	SN74192N
U25	230134	INTEGRATED CIRCUIT	SN7425N	01295	SN7425N
U26	230074	INTEGRATED CIRCUIT	SN7442N	07716	SN7442N
U27	230071	INTEGRATED CIRCUIT	SN7445N	01295	SN7445N
U28	230115	INTEGRATED CIRCUIT	SN7409N	01295	SN7409N
U29	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
U30	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
U31	230116	INTEGRATED CIRCUIT	SN7432N	01295	SN7432N
U32	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
U33	230072	INTEGRATED CIRCUIT	SN7474N	01295	SN7474N
U34	230072	INTEGRATED CIRCUIT	SN7474N	01295	SN7474N
U35	230037	INTEGRATED CIRCUIT	SN7490N	01295	SN7490N
U36	230054	INTEGRATED CIRCUIT	LM301A	27014	LM301A
U37	230054	INTEGRATED CIRCUIT	LM301A	27014	LM301A
U38	230056	INTEGRATED CIRCUIT	μA710C	07263	U6A7710393
U39	230165	INTEGRATED CIRCUIT	LM301A	27014	LM301A
U40	230165	INTEGRATED CIRCUIT	LM301A	27014	LM301A
U41	230103	INTEGRATED CIRCUIT	LM308	27014	LM308
U42	230119	INTEGRATED CIRCUIT	μA741C	07263	μA741C
U43	230144	INTEGRATED CIRCUIT	LM309KC	27014	LM309KC
U44	230072	INTEGRATED CIRCUIT	SN7474N	01295	SN7474N
W1	600245	JUMPER	L-2007-1LP		L-2007-1LP
W2	600245	JUMPER	L-2007-1LP		L-2007-1LP
W4	600245	JUMPER	L-2007-1LP		L-2007-1LP
Y1	920599	CRYSTAL	2 MHz	13571	

403689 -- Assy., REAR PANEL (Figure 6.16)

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
C56	100111	CAP	CERAM	.01 MFD	2000 V	71471	HVD6-2KV
C57	100111	CAP	CERAM	.01 MFD	2000 V	71471	HVD6-2KV
F1	920204	FUSE	SLO-BLO	.5 AMP	(115V OPERATION)	75915	3AG1/2ASB
	920756	FUSE	SLO-BLO	.25 AMP	(230V OPERATION)	75915	MDL1/4
J200	600619	CONN	RECPTLE	AC		82389	EAC-301
P7	600379	PLUG	NYLON	3 PIN		27264	1625-3R
P7 - Pin 1	600380	PIN	MALE			27264	SD-1560
P7 - Pins 2 & 3	600381	PIN	FEMALE			27264	SD-1561
P8	600687	RECPTLE	12 PIN			27264	1360-R-1
P8 - Pin 1	600651	TERMINAL PIN		MALE		27264	1434
P8 - Pins 2-6, 8-12	600650	TERMINAL PIN		FEMALE		27264	1433
S5*	600746	SWITCH	ROCKER	6 A	250 V	21793	600746
S6	600635	SWITCH	SLIDE	TPTT		22753	SW433HTH
S7	600636	SWITCH	SLIDE	4PDT		22753	SW442HTH
T1	300075	TRANSFORMER				23095	12239

*Located on Front Panel

403809 – Assy., PCB, DISPLAY

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
LED1	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
LED2	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
LED3	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
LED4	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
LED5	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
LED6	210060	LED, DISPLAY HP5082-7730	50434	HP5082-7730
R1	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R2	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R3	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R4	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R5	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R6	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R7	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R8	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R9	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R10	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R11	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R12	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R13	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R14	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R15	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R16	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R17	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R18	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R19	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R20	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J

403639 – Assy., PCB, OHMS CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C2	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C3	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C4	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C5	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C6	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C7	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C8	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C9	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C10	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C11	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
CR1	211083	DIODE	SILICO		018		21793	211083
CR2	211083	DIODE	SILICO		018		21793	211083
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	220007	DIODE	SILICO	ZENER			81349	1N751A
CR5	220026	DIODE		ZENER			81349	1N963B
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	211083	DIODE	SILICO		018		21793	211083
CR9	211083	DIODE	SILICO		018		21793	211083
CR10	211083	DIODE	SILICO		018		21793	211083
CR11	211083	DIODE	SILICO		018		21793	211083
CR12	211083	DIODE	SILICO		018		21793	211083
CR13	211083	DIODE	SILICO		018		21793	211083
CR14	220015	DIODE	SILICO	ZENER	1N967B		81349	1N967B
CR15	220031	DIODE	SILICO	ZENER	1/4M3.3AZ5		04713	1/4M3.3AZ5
CR16	211083	DIODE	SILICO		018		21793	211083
CR17	211083	DIODE	SILICO		018		21793	211083
K1	310036	RELAY	REED		R2096-3		15636	R2096-3
K2	310036	RELAY	REED		R2096-3		15636	R2096-3
K3	310036	RELAY	REED		R2096-3		15636	R2096-3
K4	310036	RELAY	REED		R2096-3		15636	R2096-3
K5	310036	RELAY	REED		R2096-3		15636	R2096-3
AR1	230054	INTEGRATED CIRCUIT			LM301A		27014	LM301A
AR2	230054	INTEGRATED CIRCUIT			LM301A		27014	LM301A
Q1	200068	TRANS			2N4250		80131	2N4250
Q2	200068	TRANS			2N4250		80131	2N4250
Q3	200199	TRANS	DUAL		200199		21793	200199

403639 – Assy., PCB, OHMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
Q4	200200	TRANS		NPN	200200		21793	200200
Q5	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q6	200200	TRANS		NPN	200200		21793	200200
R1	010529	RES	METAL	10 K	T-0	1% 1/10W	81349	RN55D1002F
R2	000106	RES	CARBON	10 M		5% 1/4W	81349	RC07GF106J
R3	010020	RES	METAL	4.99 K	T-0	1% 1/8W	81349	RN60D4991F
R4	000106	RES	CARBON	10 M		5% 1/4W	81349	RC07GF106J
R5	040228	POT	CERMET	500 OHM		10%	73138	89PR500
R6	011253	RES	METAL	4.75 K	T-0	1% 1/8W	81349	RN60D4751F
R7	000515	RES	CARBON	5.1 M		5% 1/4W	81349	RC07GF515J
R8	040235	POT	CERMET	100 K	89PR100K		73138	89PR100K
R9	040229	POT	CERMET	1 K		10%	73138	89P Series
R10	040225	POT	CERMET	50 OHM		20%	73138	89P Series
R11	040228	POT	CERMET	500 OHM		10%	73138	89PR500
R12	020650	RES	WW	221.72 K		.1% 1/4W	22045	J-120
R13	020646	RES	WW	8.0071 K		.1% 10 W	21551	M-100
R14	020649	RES	WW	79.75 K		.1% 1 W	22045	J-190
R15	040225	POT	CERMET	50 OHM		20%	73138	89P Series
R16	040232	POT	CERMET	10 K		10%	73138	89PR10K
R17	020645	RES	WW	1.7891 K		.5% 3 W	21551	M-19
R18	010796	RES	METAL	1.915 M		.1% 1W	81349	RN75E
R19	020647	RES	WW	8.5083 K		.1% 1/4W	22045	J-120
R20	040225	POT	CERMET	50 OHM		20%	73138	89P Series
R21	020648	RES	WW	10 K		10% 10 W	07716	PW10A
R22	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E
R23	600245	JUMPER			L-2007-1LP			L-2007-1LP
R24	040230	POT	CERMET	2 K		10%	73138	89PR2K
R25	010091	RES	METAL	11 K	T-0	1% 1/8W	81349	RN60D1102F
R26	010790	RES	METAL	36.5 K		1% 1/10W	81349	RN55E
R27	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R28	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R29	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R30	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R3i	000153	RES	CARBON	15 K		5% 1/4W	81349	RC07GF153J
R32	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R33	600245	JUMPER			L-2007-1LP			L-2007-1LP

403640 – Assy., PCB, AC CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
B1	920563	BEAD	SHIELDING		56-59065-4B		02114	56-59065-4B
B2	920563	BEAD	SHIELDING		56-59065-4B		02114	56-59065-4B
B3	920563	BEAD	SHIELDING		56-59065-4B		02114	56-59065-4B
C1	120280	CAP	MYLAR	.22 MFD	1000 V	10%	27556	ZA2J224K
C2	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C3	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C4	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C5	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C6	110023	CAP	TANTA	2.2 MFD	35 V	10%	05397	T310B225K035AS
C7	111148	CAP	ELECT	100 MFD	25 V		34553	ET101X025A5
C8	110154	CAP	TANTA	68 MFD	6 V	20%	05397	T368B686M006AS
C9	101644	CAP	CERAM	200 PFD	1000 V	20%	71471	GPDX5F201K
C10	110143	CAP	TANTA	1 MFD	35 V		05397	T368A105M035AS
C12	101644	CAP	CERAM	200 PFD	1000 V	20%	71471	GPDX5F201K
C13	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C14	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C16	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C17	120300	CAP	MYLAR	1.5 MFD	100 V	20%	73445	C281AH/A1M5
C18	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C19	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C20	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C21	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	TG-S20
C22	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C23	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C24	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP
C25	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C26	130146	CAP	TRIMMER	.25-1.5 PFD			74970	273-0001-002
C27	100096	CAP	CERAM	5.6 PFD	500 V	5%	71471	D1-1 NPO
C28	100050	CAP	CERAM	2.2 PFD	1000 V	5%	56289	10TCCV22
C29	130124	CAP	TRIMMER	1.2-10 PFD	250 V			R-TRIKO-122-09SD
C30	100100	CAP	CERAM	FSV	100100		21793	100100
C31	120153	CAP	POLY	47 PFD	125 V	10%	26625	611
C32	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C33	100100	CAP	CERAM	FSV	100100		21793	100100
C34	130148	CAP	TRIMMER	5-20 PFD	250 V			R-TRIKO-122-09MG
C35	120316	CAP	POLY	680 PFD	630 V	5%	08257	KSO Series
C36	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
C37	120135	CAP	POLY	.015 MFD	33 V	10%	26625	611.3S
C38	100023	CAP	CERAM	.01 MFD	100 V		71471	Type TTP

403640 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR2	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR3	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR4	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	220022	DIODE	SILICO	ZENER	15 V		81349	1N965B
CR9	220022	DIODE	SILICO	ZENER	15 V		81349	1N965B
CR10	220022	DIODE	SILICO	ZENER	15 V		81349	1N965B
CR11	211083	DIODE	SILICO		018		21793	211083
K1	310036	RELAY	REED		R2096-3		15636	R2096-3
K2	310036	RELAY	REED		R2096-3		15636	R2096-3
K3	310036	RELAY	REED		R2096-3		15636	R2096-3
Q1	200107	TRANS			2N4302		80131	2N4302
Q2	200163	TRANS	SILICO	NPN	EN916		07263	EN916
Q3	200201	TRANS	DUAL	NPN	200201		21793	200201
Q4	200096	TRANS			2N4917		81349	2N4917
Q5	200096	TRANS			2N4917		81349	2N4917
Q6	200096	TRANS			2N4917		81349	2N4917
Q7	200096	TRANS			2N4917		81349	2N4917
Q8	200163	TRANS	SILICO	NPN	EN916		07263	EN916
R1	010794	RES	METAL	1 M	Matched Set	.1%	21793	010794
R2	000683	RES	CARBON	68 K		5% 1/4W	81349	RC07GF683J
R3	000363	RES	CARBON	36 K		5% 1/4W	81349	RC07GF363J
R4	000104	RES	CARBON	100 K		5% 1/4W	81349	RC07GF104J
R5	000472	RES	CARBON	4.7 K		5% 1/4W	81349	RC07GF472J
R6	000363	RES	CARBON	36 K		5% 1/4W	81349	RC07GF363J
R7	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R8	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R9	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R10	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R11	000270	RES	CARBON	27 OHM		5% 1/4W	81349	RC07GF270J
R12	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R13	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R14	000223	RES	CARBON	22 K		5% 1/4W	81349	RC07GF223J
R15	000245	RES	CARBON	2.4 M		5% 1/4W	81349	RC07GF245J
R16	000361	RES	CARBON	360 OHM		5% 1/4W	81349	RC07GF361J
R17	000562	RES	CARBON	5.6 K		5% 1/4W	81349	RC07GF562J

403640 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R18	000433	RES	CARBON	43 K		5%	1/4W	81349	RC07GF433J
R19	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R20	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R21	000301	RES	CARBON	300 OHM		5%	1/4W	81349	RC07GF301J
R22	000270	RES	CARBON	27 OHM		5%	1/4W	81349	RC07GF270J
R23	000301	RES	CARBON	300 OHM		5%	1/4W	81349	RC07GF301J
R24	000331	RES	CARBON	330 OHM		5%	1/4W	81349	RC07GF331J
R28	010793	RES	METAL	250 OHM	Matched Set	.1%		21793	010793
R29	010793	RES	METAL	250 OHM	Matched Set	.1%		21793	010793
R30	010793	RES	METAL	50 OHM	Matched Set	.1%		21793	010793
R31	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R32	000562	RES	CARBON	5.6 K		5%	1/4W	81349	RC07GF562J
R33	010744	RES	METAL	40 K	Pair with R34	.1%		21793	010744
R34	010744	RES	METAL	40 K	Pair with R33	.1%		21793	010744
R35	010744	RES	METAL	40 K	Pair with R36	.1%		21793	010744
R36	010744	RES	METAL	40 K	Pair with R35	.1%		21793	010744
R37	010743	RES	METAL	20 K	Pair with R38	.1%		21793	010743
R38	010743	RES	METAL	20 K	Pair with R37	.1%		21793	010743
R39	010792	RES	METAL	200 K	Pair with R40	.1%		21793	010792
R40	010792	RES	METAL	200 K	Pair with R39	.1%		21793	010792
R41	040233	POT	CERMET	20 K		10%		73138	89PR20K
R42	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R43	000390	RES	CARBON	39 OHM		5%	1/4W	81349	RC07GF390J
R44	040229	POT	CERMET	1 K		10%		73138	89P Series
R45	010643	RES	METAL	71.5 K	T-0	1%	1/10W	81349	RN55D7152F
R46	010794	RES	METAL	111.19 K	Matched Set	.1%		21793	010794
R47	040229	POT	CERMET	1 K		10%		73138	89P Series
R48	010794	RES	METAL	12.305 K	Matched Set	.1%		21793	010794
R49	040226	POT	CERMET	100 OHM		10%		73138	89P Series
R50	010794	RES	METAL	1.163 K	Matched Set	.1%		21793	010794
R51	040230	POT	CERMET	2 K		10%		73138	89PR2K
R52	010795	RES	METAL	13.7 K		1%	1/10W	81349	RN55C
R53	600245	JUMPER			L-2007-1LP				L-2007-1LP
R54	010794	RES	METAL	61.77 OHM	Matched Set	.1%		21793	010794
R55	001737	RES	CARBON	FSV	001737	5%	1/4W	21793	001737
U1	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C

403775 – Assy., PCB, RMS CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
B1	920563	BEADS	SHIELDING		56-59065/4B		02114	56-59065/4B
C1	130116	CAP	MICA	4000 PFD	500 V	2%	72136	DM19F402G0
C2	130115	CAP	MICA	346 PFD	500 V	2%	72136	DM15F3460G0
C3	100081	CAP	CERAM	4.7 PFD	1000 V		56289	C030B102E4R7D
C4	130124	CAP	TRIMMER	1.2-10 PFD	250 V			R-TRIKO-122-09SD
C5	100081	CAP	CERAM	4.7 PFD	1000 V		56289	C030B102E4R7D
C6	100054	CAP	CERAM	27 PFD	1000 V	5%	56289	10TCCQ27
C7	130123	CAP	TRIMMER	1-3 PFD	250 V			R-TRIKO-122-09SD
C8	100095	CAP	CERAM	2.7±.5 PFD	500 V		56289	C030B102S2R7D
C9	130146	CAP	TRIMMER	.25-1.5 PFD	273-0001-002		74970	273-0001-002
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C11	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C12	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C13	100051	CAP	CERAM	3 PFD	500 V		71471	TCD-B1-0
C14	101641	CAP	CERAM	470 PFD		10%	71471	SCD1X5F
C15	110140	CAP	TANTA	47 MFD	6 V		05397	T368B476M006AS
C16	101641	CAP	CERAM	470 PFD	1000 V	10%	71471	SCD1X5F
C17	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C18	130076	CAP	MICA	200 PFD	500 V	5%	72136	DM15-201J
C19	101642	CAP	CERAM	150 PFD		10%	71471	SCD1X5F
C20	120294	CAP	MYLAR	.47 MFD	100 V	20%	73445	C281AH/A470K
C21	120294	CAP	MYLAR	.47 MFD	100 V	20%	73445	C281AH/A470K
C22	120294	CAP	MYLAR	.47 MFD	100 V	20%	73445	C281AH/A470K
C23	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C24	110043	CAP	ELECT	22 MFD	25 V		34553	ET220X025A3
C25	120280	CAP	MYLAR	.22 MFD	1000 V	10%	27556	ZA2J224K
C26	100095	CAP	CERAM	2.7±.5 PFD	500 V		56289	C030B102S2R7D
C27	100122	CAP	TRIMMER	1 PFD	1000 V		72136	DM19F132J
C28	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C29	101641	CAP	CERAM	470 PFD		10%	71471	SCD1X5F
C30	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C31	100084	CAP	CERAM	1.5 ± .5 PFD	1000 V		56289	10TCCV15
CR1	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR2	210015	DIODE			HP5082-2800		50434	HP5082-2800
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	211083	DIODE	SILICO		018		21793	211083
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	211083	DIODE	SILICO		018		21793	211083
CR9	220016	DIODE	SILICO	ZENER	1N964B		81349	1N964B
CR10	220016	DIODE	SILICO	ZENER	1N964B		81349	1N964B
CR11	211083	DIODE	SILICO		018		21793	211083

403775 – Assy., PCB, RMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
K1	310078	RELAY	REED		R2690-3			15636	R2690-3
K2	310036	RELAY	REED		R2096-3			15636	R2096-3
K3	310078	RELAY	REED		R2690-3			15636	R2690-3
Q1	200200	TRANS		NPN	200200			21793	200200
Q2	200200	TRANS		NPN	200200			21793	200200
Q3	200199	TRANS	DUAL		200199			21793	200199
Q4	200200	TRANS		NPN	200200			21793	200200
Q5	200201	TRANS	DUAL	NPN	200201			21793	200201
Q6	200112	TRANS		MATCHED SET				21793	200112
Q7	200112	TRANS		MATCHED SET				21793	200112
Q8	200068	TRANS			2N4250			80131	2N4250
Q9	200200	TRANS		NPN	200200			21793	200200
Q10	403865	KIT	MATCHED LOG TRANSISTOR					21793	403865
Q11	200220	TRANS	DUAL		200220			21793	200220
Q12	200136	TRANS			2N5963			81349	2N5963
Q13	200068	TRANS			2N4250			80131	2N4250
Q14	403865	KIT	MATCHED LOG TRANSISTOR					21793	403865
Q15	200197	TRANS	SILICO	NPN	MPS-H10			04713	MPS-H10
Q16	200197	TRANS	SILICO	NPN	MPS-H10			04713	MPS-H10
R1	010721	RES	METAL	MATCHED SET				21793	010721
R2	010720	RES	METAL	9.09 K	T-2	.25%	1/10W	81349	RN55C9091C
R3	040228	POT	CERMET	500 OHM		10%		73138	89PR500
R4	000820	RES	CARBON	82 OHM		5%	1/4W	81349	RC07GF820J
R5	010721	RES	METAL	MATCHED SET				21793	010721
R6	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R7	010721	RES	METAL	MATCHED SET				21793	010721
R8	040228	POT	CERMET	500 OHM		10%		73138	89PR500
R9	010721	RES	METAL	MATCHED SET				21793	010721
R10	000242	RES	CARBON	2.4 K		5%	1/4W	81349	RC07GF242J
R11	010678	RES	METAL	60.4 K		1%	1/10W	81349	RN55C
R12	040231	POT	CERMET	5 K		10%		73138	89PR5K
R13	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R14	010678	RES	METAL	60.4 K		1%	1/10W	81349	RN55C
R15	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R16	000334	RES	CARBON	330 K		5%	1/4W	81349	RC07GF334J
R17	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R18	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R19	010586	RES	METAL	5 K		.02%		18612	V53-1M
R20	000105	RES	CARBON	1 M		5%	1/4W	81349	RC07GF105J
R21	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J

403775 – Assy., PCB, RMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R22	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R23	010586	RES	METAL	5 K		.02%		18612	V53-1M
R24	010654	RES	METAL	20 K		.05%		18612	V53-1
R25	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R26	000184	RES	CARBON	180 K		5%	1/4W	81349	RC07GF184J
R27	010684	RES	METAL	487 OHM	T-9	1%	1/10W	81349	RN55E4870F
R28	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R29	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R30	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R31	000272	RES	CARBON	2.7 K		5%	1/4W	81349	RC07GF272J
R32	010615	RES	METAL	10 K		.02%		18612	V53-1M
R33	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R34	010684	RES	METAL	487 OHM	T-9	1%	1/10W	81349	RN55E4870F
R35	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R36	000681	RES	CARBON	680 OHM		5%	1/4W	81349	RC07GF681J
R37	000476	RES	CARBON	47 M		5%	1/4W	81349	RC07GF476J
R38	040239	POT	CERMET	1 M		20%		73138	89PR1M
R39	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R40	000470	RES	CARBON	47 OHM		5%	1/4W	81349	RC07GF470J
R41	040232	POT	CERMET	10 K		10%		73138	89PR10K
R42	010635	RES	METAL	34.8 K		1%	1/10W	81349	RN55D3482F
R43	010392	RES	METAL	20 K	T-2	.1%		03888	PME55
R44	000332	RES	CARBON	3.3 K		5%	1/4W	81349	RC07GF332J
R45	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R46	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R47	000104	RES	CARBON	100 K		5%	1/4W	81349	RC07GF104J
R48	001768	RES	CARBON	3.3 OHM		5%	1/4W	01121	See Descrpt.
R49	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R50	020667	RES	WW	100 K		.1%	1/8W	22045	J-110
R51	010654	RES	METAL	20 K		.05%		18612	V53-1
R52	010654	RES	METAL	20 K		.05%		18612	V53-1
R53	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R54	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R55	040227	POT	CERMET	200 OHM		10%		73138	89P Series
R56	010615	RES	METAL	10 K		.02%		18612	V53-1M
R57	010721	RES	METAL	MATCHED SET				21793	010721
R58	010618	RES	METAL	200 K		.25%	1/10W	81349	RN55C2003C
R59	403819	KIT	MATCHED LOG TRANSISTOR					21793	403819
R60	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R61	010496	RES	METAL	1 M	T-0	1%	1/8W	81349	RN60D
R62	403819	KIT	MATCHED LOG TRANSISTOR					21793	403819
R63	000221	RES	CARBON	220 OHM		5%	1/4W	81349	RC07GF221J

403775 – Assy., PCB, RMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R64	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R65	001737	RES CARBON FSV 5% 1/4W	21793	001737
R66	010536	RES METAL 100 K T-0 1% 1/10W	81349	RN55D1003F
R67	000513	RES CARBON 51 K 5% 1/4W	81349	RC07GF513J
S1	600742	SWITCH SLIDE G-111	79727	G-111
S2	600742	SWITCH SLIDE G-111	79727	G-111
TP1	600591	POST TEST POINT 85931-6	89110	85931-6
TP2	600591	POST TEST POINT 85931-6	89110	85931-6
TP3	600591	POST TEST POINT 85931-6	89110	85931-6
TP4	600591	POST TEST POINT 85931-6	89110	85931-6
TP5	600591	POST TEST POINT 85931-6	89110	85931-6
AR1	230180	INTEGRATED CIRCUIT LM318H	27014	LM318H
AR2	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
W1	600245	JUMPER L-2007-1LP		L-2007-1LP

403641 – Assy., PCB, RATIO BUFFER

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
C1	110043	CAP	ELECT	22 MFD	25 V			34553	ET220X025A3
C2	100023	CAP	CERAM	.01 MFD	100 V			71471	Type TTP
C3	120311	CAP	POLY	.056 MFD	250 V	10%		73445	C281AB/A56K
C4	110043	CAP	ELECT	22 MFD	25 V			34553	ET220X025A3
C5	100023	CAP	CERAM	.01 MFD	100 V			71471	Type TTP
C6	120311	CAP	POLY	.056 MFD	250 V	10%		73445	C281AB/A56K
C7	101641	CAP	CERAM	470 PFD		10%		71471	SCD1X5F
C8	120290	CAP	MYLAR	.22 MFD	100 V	20%		73445	C281AH/A220K
C9	101145	CAP	CERAM	100 PFD		10%		71471	ETCD-DI-1(N5600)
C10	101641	CAP	CERAM	470 PFD		10%		71471	SCD1X5F
CR1	221177	DIODE	SILICO	ZENER	1/4M.2.4AZ5			04713	1/4M.2.4AZ5
CR2	220040	DIODE		ZENER				81349	1N753A
CR3	211083	DIODE	SILICO		018			21793	211083
CR4	211083	DIODE	SILICO		018			21793	211083
CR7	220040	DIODE		ZENER				81349	1N753A
CR8	220040	DIODE		ZENER				81349	1N753A
K1	310111	RELAY			28 V			24796	R10-E-2314-2
Q1	200200	TRANS		NPN	200200			21793	200200
Q2	200200	TRANS		NPN	200200			21793	200200
Q3	200201	TRANS	DUAL	NPN	200201			21793	200201
Q4	200200	TRANS		NPN	200200			21793	200200
Q5	200171	TRANS	FET		2N4302			80131	2N4302
Q6	200068	TRANS			2N4250			80131	2N4250
Q7	200200	TRANS		NPN	200200			21793	200200
Q8	200200	TRANS		NPN	200200			21793	200200
Q9	200200	TRANS		NPN	200200			21793	200200
Q10	200200	TRANS		NPN	200200			21793	200200
Q11	200200	TRANS		NPN	200200			21793	200200
Q12	200200	TRANS		NPN	200200			21793	200200
R1	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R2	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R3	040230	POT	CERMET	2 K		10%		73138	89PR2K
R4	010736	RES	METAL	1 M	Matched Set	.1%		21793	010736
R5	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R6	040230	POT	CERMET	2 K		10%		73138	89PR2K
R7	000302	RES	CARBON	3 K		5%	1/4W	81349	RC07GF302J
R8	040236	POT	CERMET	200 K		10%		73138	89P200K
R9	010295	RES	METAL	2 M	T-0	1%	1/4W	81349	RN65D2004F

403641 – Assy., PCB, RATIO BUFFER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R10	010295	RES METAL 2 M T-0 1% 1/4W	81349	RN65D2004F
R11	001737	RES CARBON FSV 5% 1/4W	21793	001737
R12	001737	RES CARBON FSV 5% 1/4W	21793	001737
R13	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R14	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
R15	010384	RES METAL 402 K 1% 1/8W	81349	RN60D4023F
R16	010736	RES METAL 1 M Matched Set .1%	21793	010736
R17	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R18	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R19	001261	RES CARBON 2 K 5% 1/2W	81349	RC20GF202J
R21	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R22	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R23	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R24	000134	RES CARBON 130 K 5% 1/4W	81349	RC07GF134J
R31	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
R32	000473	RES CARBON 47 K 5% 1/4W	81349	RC07GF473J
AR1	230103	INTEGRATED CIRCUIT LM308	27014	LM308
U2	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
W1	600245	JUMPER L-2007-1LP		L-2007-1LP
W2	600245	JUMPER L-2007-1LP		L-2007-1LP

403643 – Assy., PCB, DATA OUTPUT & PROGRAMMING

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C1	110121	CAP	ELECT	2200 MFD	10 V		34553	ET222X010A03
C2	110121	CAP	ELECT	2200 MFD	10 V		34553	ET222X010A03
C3	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C4	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C5	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C6	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C7	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
C8	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C9	120294	CAP	MYLAR	.47 MFD	100 V	20%	73445	C281AH/A470K
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C11	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C12	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C13	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C14	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C17	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C18	101174	CAP	CERAM	.001 MFD	500 V	10%	71471	SCD3X5F
C19	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C20	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C21	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C22	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C23	120290	CAP	MYLAR	.22 MFD	100 V	20%	73445	C281AH/A220K
CR1	210004	DIODE	SILICO		1N4004		81349	1N4004
CR2	210004	DIODE	SILICO		1N4004		81349	1N4004
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	211083	DIODE	SILICO		018		21793	211083
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	221177	DIODE	SILICO	ZENER	2.4 V		04713	1/4M.2.4AZ5
J6	600658	CONN	22 PIN		2-583486-9		89110	2-583486-9
LED1	250000	LED			TIL108		01295	TIL108
LED2	250000	LED			TIL108		01295	TIL108
LED3	250000	LED			TIL108		01295	TIL108
LED4	250000	LED			TIL108		01295	TIL108
LED5	250000	LED			TIL108		01295	TIL108
Q1	200200	TRANS		NPN	200200		21793	200200
Q2	200200	TRANS		NPN	200200		21793	200200
Q3	200200	TRANS		NPN	200200		21793	200200

403643 – Assy., PCB, DATA OUTPUT & PROGRAMMING *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
Q4	200200	TRANS NPN 200200	21793	200200
Q5	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q6	200200	TRANS NPN 200200	21793	200200
Q7	200200	TRANS NPN 200200	21793	200200
Q8	200200	TRANS NPN 200200	21793	200200
Q9	200200	TRANS NPN 200200	21793	200200
R1	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R2	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R3	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R4	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R5	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R6	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R7	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R8	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R9	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R10	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R11	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R12	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R13	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R14	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R15	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R16	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R17	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R18	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R19	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R20	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R21	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R22	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R23	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R24	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R25	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R26	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R27	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R28	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R29	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R30	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R31	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R32	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R33	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R34	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R35	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J

403643 – Assy., PCB, DATA OUTPUT & PROGRAMMING *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R36	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R37	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R38	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R39	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R40	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R41	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R42	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R44	000391	RES CARBON 390 OHM 5% 1/4W	81349	RC07GF391J
R45	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R46	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R47	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R48	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R49	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R50	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R51	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R52	000471	RES CARBON 470 OHM 5% 1/4W	81349	RC07GF471J
R53	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R54	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R55	000331	RES CARBON 330 OHM 5% 1/4W	81349	RC07GF331J
R56	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R57	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R58	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R59	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R60	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R61	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R62	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R63	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R64	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R65	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R66	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R67	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R68	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R69	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R70	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R71	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
T1	403552	TRANSFORMER PULSE 403552	21793	403552
T2	403552	TRANSFORMER PULSE 403552	21793	403552
T3	403552	TRANSFORMER PULSE 403552	21793	403552
T4	403552	TRANSFORMER PULSE 403552	21793	403552
T5	403552	TRANSFORMER PULSE 403552	21793	403552

403643 – Assy., PCB, DATA OUTPUT & PROGRAMMING *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
TP1	600591	POST TEST POINT 85931-6	89110	85931-6
TP2	600591	POST TEST POINT 85931-6	89110	85931-6
U1	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U2	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U3	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U4	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U5	230076	INTEGRATED CIRCUIT SN74L00N	01295	SN74L00N
U6	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U7	230073	INTEGRATED CIRCUIT SN7405N	01295	SN7405N
U8	230073	INTEGRATED CIRCUIT SN7405N	01295	SN7405N
U9	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U10	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U11	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U12	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U13	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U14	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U15	230121	INTEGRATED CIRCUIT SN74L90N	01295	SN74L90N
U16	230139	INTEGRATED CIRCUIT SN74L42N	01295	SN74L42N
U17	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U18	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U19	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U20	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U21	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U22	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U23	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U24	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U25	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U26	230142	INTEGRATED CIRCUIT SN74L75N	01295	SN74L75N
U27	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U28	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U29	230141	INTEGRATED CIRCUIT SN74L74N	01295	SN74L74N
U30	230076	INTEGRATED CIRCUIT SN74L00N	01295	SN74L00N
U31	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U32	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U33	230136	INTEGRATED CIRCUIT SN74L02N	01295	SN74L02N
U34	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U35	230141	INTEGRATED CIRCUIT SN74L74N	01295	SN74L74N
U36	230141	INTEGRATED CIRCUIT SN74L74N	01295	SN74L74N
U37	230138	INTEGRATED CIRCUIT SN74L04N	01295	SN74L04N
U38	230141	INTEGRATED CIRCUIT SN74L74N	01295	SN74L74N
U39	230141	INTEGRATED CIRCUIT SN74L74N	01295	SN74L74N

403643 – Assy., PCB, DATA OUTPUT & PROGRAMMING *continued*

REF DES	DANA P/N	DESCRIPTION		FSC	MANU P/N
U40	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U41	230135	INTEGRATED CIRCUIT	SN7427N	01295	SN7427N
U42	230076	INTEGRATED CIRCUIT	SN74L00N	01295	SN74L00N
U43	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U44	230139	INTEGRATED CIRCUIT	SN74L42N	01295	SN74L42N
U45	230121	INTEGRATED CIRCUIT	SN74L90N	01295	SN74L90N
U46	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U47	230136	INTEGRATED CIRCUIT	SN74L02N	01295	SN74L02N
U48	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U49	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U50	230136	INTEGRATED CIRCUIT	SN74L02N	01295	SN74L02N
U51	230121	INTEGRATED CIRCUIT	SN74L90N	01295	SN74L90N
U52	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U53	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U54	230141	INTEGRATED CIRCUIT	SN74L74N	01295	SN74L74N
U55	230136	INTEGRATED CIRCUIT	SN74L02N	01295	SN74L02N
U56	230139	INTEGRATED CIRCUIT	SN74L42N	01295	SN74L42N
U57	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U58	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U59	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U60	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U61	230064	INTEGRATED CIRCUIT	SN7404N	01295	SN7404N
U62	230137	INTEGRATED CIRCUIT	SN74L03N	01295	SN74L03N
U63	230140	INTEGRATED CIRCUIT	SN74L73N	01295	SN74L73N
U64	230138	INTEGRATED CIRCUIT	SN74L04N	01295	SN74L04N
U65	230076	INTEGRATED CIRCUIT	SN74L00N	01295	SN74L00N
U66	230136	INTEGRATED CIRCUIT	SN74L02N	01295	SN74L02N
U67	230136	INTEGRATED CIRCUIT	SN74L02N	01295	SN74L02N
U68	230076	INTEGRATED CIRCUIT	SN74L00N	01295	SN74L00N
U69	230076	INTEGRATED CIRCUIT	SN74L00N	01295	SN74L00N
U70	230144	INTEGRATED CIRCUIT	LM309KC	27014	LM309KC

U.S. AND CANADIAN SERVICE CENTERS

FACTORY SERVICE LOCATIONS

A DANA LABORATORIES, INC.
2401 Campus Drive
Irvine, California 92664
Telephone: (714) 833-1234

B DANA NEW ENGLAND
591 North Ave., Door 3
Wakefield, Massachusetts 01880
Telephone: (617) 246-1590

AUTHORIZED SERVICE CENTERS

1 BALL BROTHERS RESEARCH CORP
P.O. Box 1062
Boulder Industrial Park
Boulder, Colorado 80302
Telephone: (303) 441-4000

2 DMA ENGINEERING SERVICES
4235 Proton Road
Dallas, Texas 75240
Telephone: (214) 661-0300

3 HONEYWELL, INC.
4501 West 160th Street
Cleveland, Ohio 44135
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6 2930 W. Fairmount
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14 VALLEY INSTRUMENT COMPANY
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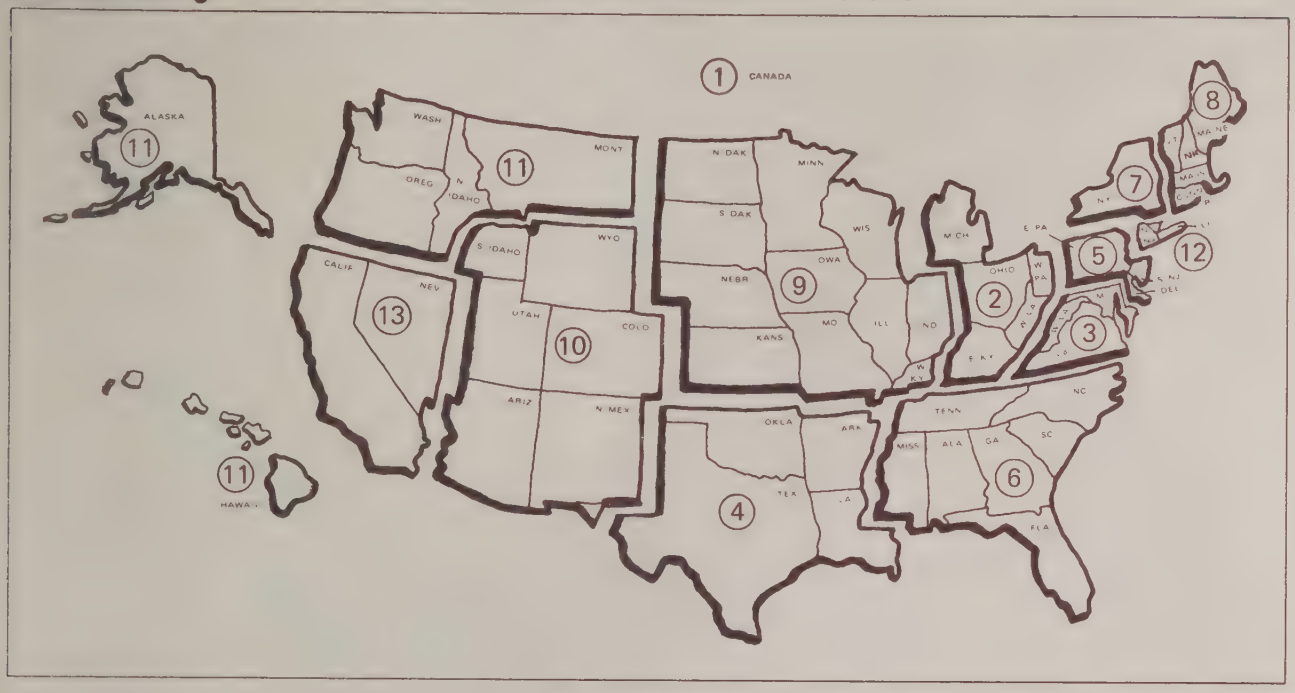

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4 DATA MARKETING ASSOC.

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300 Huntland Avenue, Suite 210
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TWX: None

5 EASTERN INSTRUMENTATION OF PHILADELPHIA

613 West Cheltenham Avenue
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428 Alamance Road
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St. Louis, Missouri 63141
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Shawnee Mission, Kansas 66202
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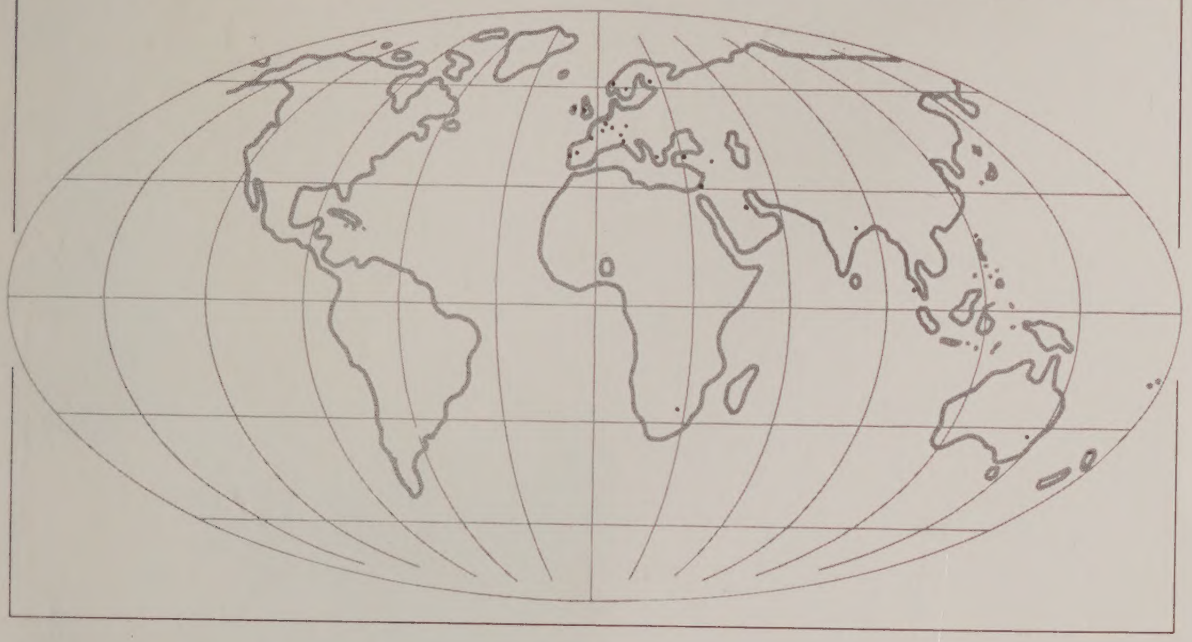

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England
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FINLAND
Finn Metric Oy
Ahertajantie 6 D
02101 Tapiola PL 6, Finland
Telephone: 90-460-844
Telex: 122018 TRIC SF

FRANCE
Dana Laboratories, SARL
91 Route des Gardes
92 Meudon-Bellevue, France
Telephone: 1027-2431
Telex: 20207 DANA FRA 20207F

GERMANY
Dana Laboratories, GmbH
Riedstrasse 8C
6100 Darmstadt, Germany
Telephone: 650546
Telex: 419644 DANA D

GREECE
American Technical Enterprises
Tositsa 7
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Athens 148, Greece
Telephone: 21/819470
Telex: 216046 ATE GR

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Telephone: 39/2-4982451
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Societe Commerciale Radioelectrique Marocaine
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NETHERLANDS
Simac Electronics B.V.
Eindhovenseweg 58
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Telephone: 04-970-2011
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NEW ZEALAND
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O'Connor's (Pte) Limited
O'Connor House
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SOUTH AFRICA
Associated Electronics, Ltd.
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18500 Vaxholm, Sweden
Telephone: 764-31580
Telex: 11309 SAVENIC S

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4 Levent, Istanbul, Turkey
Telephone: 64 30 05
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UNITED KINGDOM
Dana Electronics, Limited
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Luton, Bedfordshire, England
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YUGOSLAVIA
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Avenue des Mimosas 83
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